DOCUMENT RESUME

ED 120 021 SE 020 597

AUTHOR	Helgeson, Stanley L., Ed.
TITLE	National Association for Research in Science Teaching 49th Annual Meeting, Abstracts of Presented Papers.
INSTITUTION	ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, Columbus, Ohio.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
PUB DATE	Apr 76
NOTE	173p.
AVAILABLE FROM	Information Reference Center (ERIC/IRC), The Ohio State University, 1200 Chambers Road, 3rd Floor, Columbus, Ohio 43212 ($3.00)
EDRS PRICE	MF-$0.83 HC-$8.69 Plus Postage
DESCRIPTORS	*Abstracts; *Conference Reports; Conferences; *Educational Research; Reference Materials; *Science Education; Speeches
IDENTIFIERS	NARST; *National Association Research Science Teaching

ABSTRACT

This publication provides abstracts of papers presented at the 49th annual meeting of the National Association for Research in Science Teaching (NARST) held in San Francisco, April 23-25, 1976. The entries represent a wide range of topics in the field of science education. The themes recurring most often are related to the fields of: (1) competency-based education, (2) concept development, (3) learning theory, and (4) teacher education. Abstracts include presentations at symposia, concurrent and training sessions, and contributed papers. (CP)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ABSTRA
PRESEN
NARST-

ED120021

ABSTRACTS OF PRESENTED PAPERS, NARST—1976

The National Association for Research in
Science Teaching
in cooperation with
the ERIC Science, Mathematics and
Environmental Education Clearinghouse and the
Center for Science and Mathematics Education
The Ohio State University

ERIC/SMEAC SCIENCE, MATHEMATICS, AND ENVIRONMENTAL EDUCATION INFORMATION ANALYSIS CENTER.

. . . an information center to organize and disseminate information and materials on science, mathematics, and environmental education to teachers, administrators, supervisors, researchers, and the public. A joint project of The Ohio State University and the Educational Resources Information Center of NIE.

SE 020 597

NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING
49TH ANNUAL MEETING
ABSTRACTS OF PRESENTED PAPERS

The Sir Francis Drake Hotel
San Francisco, California
April 23-25, 1976

ERIC Information Analysis Center for
Science, Mathematics, and Environmental Education
The Ohio State University
1200 Chambers Road
Columbus, Ohio 43212

PREFACE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in San Francisco, California, April 23-25, 1976.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. O. Roger Anderson and the NARST Program Committee who obtained the abstracts and organized the program, and to Dr. Patricia Blosser for extensive assistance in preparing the abstracts.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education and other publications of the ERIC system.

April, 1976

Stanley L. Helgeson
Editor

This publication was prepared pursuant to a contract with the National Institute of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgments in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent National Institute of Education position or policy.

TABLE OF CONTENTS

PREFACE

Page

PAPERS PRESENTED AT THE CONFERENCE

- GENERAL SESSION I . . . 1
  - "Science Teaching and the Development of Reasoning" Karplus, Robert . . . 1
  - Concurrent Sessions I . . . 2
    - Session A. Informal Discussion Session . . . 2
      - Karplus, Robert . . . 2
    - Session B. Training Session: "Concept Mapping" . . . 3
      - Novak, Joseph D., James Stewart and Richard Rowell . . . 4
      - Stewart, James H. . . . 6
      - Rowell, Richard M. . . . 7
    - Session C. Training Session: "Qualitative Field Methods" . . . 8
      - Howe, Ann C. . . . 9
    - Session D. Contributed Papers: "Competency Based Teacher Education" . . . 11
      - Moore, Kenneth D. and Jacob W. Blankenship . . . 12
      - Brown, Dean R. and Ronald D. Simpson . . . 14
      - Piper, Martha K. . . . 16
      - May, David H. and Frank E. Crawley . . . 18
  - Concurrent Sessions II . . . 20
    - Session A. Symposium - "Matching Experiences to Learner Needs" . . . 20
      - Linn, Marcia C., Herbert D. Thier, Robert C. Knott, Benjamin Chen and Dennis Schatz . . . 21
    - Session B. Training Session: "Concept Mapping" - Part II . . . 24
      - Novak, Joseph D., James H. Stewart and Richard M. Rowell . . . 24
    - Session C. Contributed Papers: "Evaluation Studies" . . . 25
      - Ciesla, Jerome L. . . . 26
      - Hayward, Robert R. . . . 28
      - Monaco, William J. and Michael Szabo . . . 30
      - Smith, Walter S. . . . 32
      - Glass, Lynn W. . . . 34

Session D. Contributed Papers: "Preservice Teacher Education" . . . 36
- Strawtiz, Barbara M. . . . 38
- Martinez-Perez, Luis A. and Richard L. Campbell. . . 40
- Yeany, Russell H. Jr. . . . 41
- Crawley, Frank E. and John W. Shrum . . . 43
- Smith, Melvin O. . . . 45

Concurrent Sessions III. . . . 47

Session A. Paper Set: "Theoretical Bases for Attitude Research" . . . 47
- Shrigley, Robert L. . . . 48
- Riley, Joseph . . . 50
- Johnson, Theodore . . . 52

Session B. Contributed Papers: "Inservice Teacher Education" . . . 54
- Jaus, Harold . . . 55
- Stronck, David . . . 57
- Horak, Willis . . . 59
- Clark, Glenn and John P. Smith . . . 61

Session C. Contributed Papers: "Learning" . . . 63
- Patterson, Marvin D. . . . 64
- Simmons, Ellen S.. . . . 66
- Mosley, William and Paul E. Bell . . . 68
- Bates, Gary C. and Fletcher G. Watson . . . 69
- Leith, Sylvia and Kenneth Slentz . . . 70

Session D. Editorial Board Meeting . . . 72
- Butts, David . . . 72

Concurrent Sessions IV . . . 73

Session A. Symposium: "Formal Thinking" . . . 73
- Wollman, Warren . . . 74
- Lawson, Anton E. . . . 74
- Linn, Marcia C. . . . 75
- Renner, John . . . 75

Session B. Contributed Papers: "Inservice Teacher Education" . . . 76
- Rezba, Richard J. Anton Lahnston and Diane Lapp . . . 77
- Koran, John J., Sharon Brower and Albert W. Strickland, III. . . . 79
- Jaus, Harold H. and Gerald H. Krockover . . . 81
- Ward, William H., Jr. . . . 83

Session C. Contributed Papers: "Learning" . . . 85
- Krockover, Gerald H. and Marshall D. Malcolm . . . 87
- Schafer, Larry and Robert A. Vargo . . . 89
- Goodson, Martin L., Jr. and James R. Okey . . . 91
- Douglass, Claudia . . . 93
- Humphreys, Donald W. . . . 94

Session D. Contributed Papers: "Conceptual Models" . . 95
- Boulanger, F. David 96
- Szabo, Michael and Anthony Lazzaro 98
- Rowe, Mary Budd 101
- Tamir, Pinchas 102
- Wassef, W. A. 104

AWARD LUNCHEON. 106
- "Heuristic Learning and Science Education" Suchman, J. Richard 106

Concurrent Sessions V 107

Session A. Research Design Award Papers 107
- Novak, Joseph D. 107

Session B. Training Session: "Dynamic Cognitive Systems" 108
- Easley, Jack A., Jr., Charles M. Weller, Rosalind Driver, Klaus C. Witz, and Gary Knamiller 109

Session C. Training Session: "Research and Evaluation Designs" 110
- Okey, James R. 111

Session D. Paper Set: "Competency-Based Teacher Education" 115
- Hockett, John 116
- Zalewski, Leon J. 116
- Carter, Lynne. 117
- Lawrence, Otis 117

Concurrent Session VI 118

Session A. Paper Set: "Instructional Research in Science Education - Theory and Application" . . . 118
- Smith, Edward L. 119
- Finley, Fred N.. 121
- Dennison, Judy K. 123
- Padilla, Michael J.. 125
- Brandenburg, Richard K.. 127

Session B. Training Session: "Dynamic Cognitive Systems" - Part II 128
- Easley, Jack A., Jr., Charles M. Weller, Rosalind Driver, Klaus C. Witz, and Gary Knamiller 128

Session C. Training Session: "Research and Evaluation Designs" - Part II 129

Session D. Contributed Papers: "Curriculum" 130
- Levin, Florence and Joy S. Lindbeck 131
- Leopardi, Donato 133
- Voelker, Alan M. 135
- Ogden, William R. and Janis L. Jackson 136
- Ward, William H., Jr. 138

GENERAL SESSION II. 140
    Vaden Miles Memorial Lecture - "Teaching the Impact of Science on World Technology"
    Washton, Nathan S. 140

    Concurrent Sessions VII 141
        Session A. Symposium: "Science Education at a Funding Crossroad -- Assessment for Future Direction" . . 141
            Thompson, Ertle, Mary Budd Rowe, Robert E. Yager, Ernest Burkman, and Wayne W. Welch 142

        Session B. Contributed Papers: "Conceptual Models" . . 143
            Baker, Dennis S. and John J. Koran 144
            Lutz, John E.. 147
            Eggen, Paul, Don Kauchak and Sandra Kirk 149
            Dede, Christopher J. 151
            Durkee, George P. and George Cossman 153

        Session C. Contributed Papers: "Learning" 155
            Raven, Ronald J. 156
            Johnson, Theodore M. 158
            Berger, Carl F.. 160
            Taiwo, Diran A.. 162
            Lowell, Walter E.. 164

GENERAL SESSION I

Presiding: Ronald D. Anderson, The University of Colorado, Boulder, Colorado 80302.

Speaker: Robert Karplus, University of California, Berkeley, California 94720.

"Science Teaching and the Development of Reasoning"

CONCURRENT SESSIONS I

Session IA - Informal Discussion Session

Presiding: J. W. George Ivany, Memorial University, St. John's, Newfoundland.

"An Informal Discussion With Robert Karplus"

Robert Karplus
University of California
Berkeley, California 94720

CONCURRENT SESSION I

Session IB - Training Session: "Concept Mapping"

Presiding: Joseph D. Novak, Cornell University, Ithaca, New York 14853.

1. "The Development and Use of Concept Mapping as an Evaluation Technique and Application of Ausubel's Learning Theory." Joseph D. Novak, Cornell University, Ithaca, New York 14853.

2. "Concept/Cognitive Mapping: A Method of Evaluating Science Concept Development." James H. Stewart, Cornell University, Ithaca, New York 14853.

3. "Cognitive Mapping Analysis of Science Concept Development in Elementary School Children." Richard M. Rowell, Cornell University, Ithaca, New York 14853.

THE DEVELOPMENT AND USE OF CONCEPT MAPPING AS AN EVALUATION TECHNIQUE AND APPLICATION OF AUSUBEL'S LEARNING THEORY

Joseph D. Novak
James Stewart
Richard Rowell
Cornell University
Ithaca, New York 14853

For more than a decade our research group has used Ausubel's (1968) psychology of cognitive learning as a theoretical base for the design of research and interpretation of data. The basic dictum of Ausubel's theory is: The most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.

It has been possible to show that the quality and extent of prior knowledge *specifically relevant* to a new learning task is the most important single variable influencing learning (cf. Novak, 1975). However, as our evaluation approaches in the past have relied on more or less conventional methods of objective testing or modified Piagetian clinical interviews, we have not been satisfied with these methods of assaying either prior relevant knowledge before a learning task or program or the extent of cognitive structure development after learning. Recently we have developed the technique of "concept mapping" which we believe holds promise for better evaluation of students' relevant cognitive structure both before and after a learning task.

The evaluation technique of concept mapping requires several related steps. First we must "unpack" the concepts contained in an instructional program or segment. This involves an analysis of the materials to identify "key concepts," specific "knowledge claims" and "value claims." For example, an instructional segment dealing with photosynthesis would involve much key concepts as photosynthesis, energy, energy transformation, photons, molecular structure, diffusion, rate limiting factors, etc. Knowledge claims might include graphs or tables showing rate of radio-active O_2 released under varying conditions of light and/or CO_2 tension. Value claims are sometimes subtle, but they might include expressions on the relative importance of ocean versus terrestrial photosynthesis or role of agriculture in human food chains. Value claims answer the question, "So *what* does this all mean?" The methods of inquiry used can also be noted as well as the broader context of which the learning passage is a part, e.g. world energy balance of biochemical research studies, etc.

When the learning package is "unpacked," a "concept map" can be devised and specific knowledge claims can be shown as linked to portions of the concept map. We have found it useful to distinguish between *macro*-concept maps and *micro*-concept maps. The *macro* maps locate the concepts presented in a specific learning passage in a broader context of concepts, whereas the *micro* maps show concepts and relationships between concepts for a specific segment of instruction. The latter represent a "high resolution" picture of a segment of the *macro*-concept maps. These maps will be illustrated by the other participants in this paper set.

When concept maps are ready (this may involve several revisions as consultations between research colleagues proceed), an interview protocol is developed. The interview is then conducted with a sample of students either prior to or after instruction. Further revision of the concept maps and/or interview protocols may occur. All concept maps represent only one form of map and different investigators would undoubtedly devise somewhat different maps. We do not believe this is any more crucial to cross-interpretation of studies than now derives from the use of varying multiple-choice type or other forms of evaluation.

A sample of students can now be analyzed in terms of the number and quality of concepts developed in an instructional segment.

CONCEPT/COGNITIVE MAPPING:

A METHOD OF EVALUATING SCIENCE CONCEPT DEVELOPMENT

James H. Stewart
Cornell University
Ithaca, New York 14853

The objective of this study was to demonstrate the technique of concept/cognitive mapping as a tool in evaluating concept development in several content areas and academic levels of science instruction.

A science education research group at Cornell University has developed and used for the past ten years an Audio-Tutorial Elementary Science Program. This program is based upon the view that science is a conceptual system. Since 1972, cognitive maps have been used in evaluating the children's concepts of energy, energy transformation, continuity of life and the particulate matter of nature.

The present report details application of the concept map/cognitive map analysis in four new settings: a high school biology class; a community college biology class; a university genetics course; and an in-service course for consulting sanitary engineers. In each of the four settings three mapping steps were carried out.

1. A Concept Map - portrays the structure of the discipline.
2. First Cognitive Map - a "pre-test" that indicates the relevant entry cognitive structure for an individual student.
3. Second Cognitive Map - a "post-test" that evaluates the degree of concept differentiation that occurred during instruction.

Concept maps are generated by the instructor/evaluator, or, preferably, through consensus among individuals knowledgeable in the discipline; the maps portray the discipline in terms of concepts and concept relationships.

Cognitive maps in steps #2 and #3 were produced from cassette recordings of Piagetian clinical interviews with individual students.

Since this study was not intended to gather exhaustive empirical evidence concerning the degree of science achievement in each group, only a small sample (5-10) of student volunteers from each of the four educational levels was used. This study sampled the entry cognitive structure of students in each group and followed the differentiation over a short period of time. The study and this report are meant to be descriptive of a method.

This study, by describing a "how-to" method, may suggest useful applications for science education researchers who view science as a conceptual system and who wish to evaluate student progress in terms of concept differentiation.

COGNITIVE MAPPING ANALYSIS OF SCIENCE CONCEPT DEVELOPMENT IN ELEMENTARY SCHOOL CHILDREN

Richard M. Rowell
Cornell University
Ithaca, New York 14853

The objective of this study was to analyze the development of four major science concepts over a three year period of elementary school instruction. The concepts that this study focused upon were: *energy*, *energy transformation*, *continuity of life* and *particular nature of matter*.

A cognitive mapping technique was used as the system of analysis. This technique was preceded by instruction via an audio-tutorial elementary science program. This program is based upon a theory of concept learning facilitated by organized audio integration of learning activities.

Concept maps (diagrams depicting key concepts of the program as well as the relationship between these concepts) were produced for all units of the A-T program. Children were then interviewed using Piaget's revised clinical method. Transcriptions were made of 419 interviews; these interviews were then converted to cognitive maps (again showing key concepts and their interrelationships).

Data on each child in this study consisted of from four to six cognitive maps. These maps were ordinally rated, with the criteria being the degree to which each interview represented the scientific model described on the concept map.

Quantitative analysis of scientific model use in each of four interviews revealed the proportion of children who *always*, *never*, and *on some but not all occasions* made use of an appropriate scientific model to describe, explain, and solve problems based on several major concepts of science. Additionally, a case study approach, using a small sample of the children interviewed, was used to describe the range of model usage.

The evidence from this study suggests that the use of these selected scientific models is content specific, and does not appear to be a general ability. Implications for the structuring of elementary science programs are embodied in the results. An appropriate concept evaluation technique is demonstrated.

CONCURRENT SESSIONS I

Session IC - Training Session: "Qualitative Field Methods"

Presiding: Ann C. Howe, Syracuse University, Syracuse,
New York 13210.

1. "The Use of Qualitative Field Methods in Science Education Research." Ann C. Howe, Syracuse University, Syracuse, New York 13210

THE USE OF QUALITATIVE FIELD METHODS IN SCIENCE EDUCATION RESEARCH

Ann C. Howe
Syracuse University
Syracuse, New York 13210

The controlled laboratory experiment has been adopted as the primary model for research in science education with the result that research problems are often defined in terms of the instruments and analytical tools which are available. Faculty advisors are not infrequently approached by a student with instruments in search of a problem. There is a need to expand our repertoire of research methods so that more time may be spent on the selection of a method and approach to a significant problem and somewhat less, in some cases, on instrumentation and statistical analysis.

This training session will introduce participants to an alternative research method which is used in the social sciences and which may be more appropriate for certain problems than the method of the controlled experiment. This method is referred to as the field method--a generic term for observing events in a natural setting.

The training session will begin with a brief presentation of the philosophical and theoretical issues involved in the decision to use field research methods. This will be followed by a presentation of the topics listed below:

1. Gaining Entry to the Field
    a. Selecting a location
    b. Negotiating with hosts

2. Watching and Listening
    a. Getting organized
    b. Participant observation
    c. Watching and listening from outside
    d. Interviewing

3. Recording Data
    a. Observational notes
    b. Theoretical notes
    c. Methodological notes
    d. Packaging and filing

4. Analyzing Data
    a. Analysis as a process of thinking through the problem
    b. Generation of hypotheses

5. A Case History: The Use of Field Methods to Study a Problem in Science Education

The time allotted for a training session does not allow a detailed presentation of all techniques; those who wish to carry out a study using these methods will have to pursue the subject further on their own. This will be facilitated by the provision of a packet of materials, including an annotated bibliography, for all participants.

This method is not a specified set of procedures which must be committed to memory but, rather, an approach to investigation which affirms the investigator's ability to make some sense out of complicated interactions and behaviors through the use of his own powers of observation and thought. This may serve as a source of new insights or as a basis for future experiments.

CONCURRENT SESSIONS I

Session ID - Contributed Papers: "Competency Based Teacher Education"

Presiding: William Capie, University of Georgia, Athens, Georgia 30602.

1. "The Identification of Science Teacher Needs Through the Factor Analytic Procedure." Kenneth D. Moore, The University of Tulsa, Tulsa, Oklahoma 74104 and Jacob W. Blankenship, The University of Houston, Houston, Texas 77004.

2. "Validating Science Teaching Competencies Using the Delphi Method." Dean R. Brown, Colorado State University, Fort Collins, Colorado 80521 and Ronald D. Simpson, North Carolina State University, Raleigh, North Carolina 27607.

3. "The Investigation of Attitude Changes of Elementary Preservice Teachers and Classroom Teachers Involved in a Competency-Based, Reality-Oriented Science Methods Course." Martha K. Piper, University of Houston, Houston, Texas 77004.

4. "Assessment of the Effects of the Competency Based Teacher Education Experience on the Acquisition of a Teaching Model." David H. May, The University of Georgia 30602 and Frank E. Crawley, The University of Texas at Austin, Austin, Texas 78712.

THE IDENTIFICATION OF SCIENCE TEACHER NEEDS THROUGH THE FACTOR ANALYTIC PROCEDURE

Kenneth D. Moore
The University of Tulsa
Tulsa, Oklahoma 74104

and

Jacob W. Blankenship
The University of Houston
Houston, Texas 77004

It is generally acknowledged that the role of the science teacher is changing due to changes in science curricula, media, and materials. This changing role is resulting in a realization on the part of science teachers that they have certain cognitive, affective, and psychomotor needs and that because of these needs their effectiveness in the classroom is limited. The development of procedures for identifying and categorizing these needs has been a major concern of educational research for years.

In general, researchers have relied on questionnaires to obtain data pertaining to science teacher needs. Data obtained through the use of these questionnaires have been categorized according to common unifying themes and then utilized in the development and coordination of pre-service and in-service training programs.

The purpose of this study was to allow the investigators to study an alternative approach to the identification of science teacher needs. Specifically, the study explored the utility of the factor analytic procedure as a means of identifying science teacher needs.

The Moore Assessment Profile (MAP) was the instrument developed and used in this study. The assessment profile consists of 117 need statements which were designed to tap a wide range of science teacher needs. The Profile (MAP) was mailed to a stratified randomized sample of 500 science teachers. The responses given to each need statement underwent computerized factor analysis in order to identify the factors underlying the needs of science teachers.

The subjects of the study were 500 science teachers selected from the 21 school districts of a county whose population of 2,100,000 people represent a broad spectrum of socioeconomic levels ranging from rural agriculture to metropolitan city. The three strata samples selected were 200 elementary teachers, 150 junior high science teachers, and 150 senior high science teachers.

The data for this descriptive study were collected through the administration of the Moore Assessment Profile (MAP). The returned responses were measured and analyzed in terms of a weighted value, one through four, which corresponded to the four columns on the assessment profile.

The factor analysis resulted in the identification of twenty-three factors which, together, accounted for 73.8 percent of the total variance on the Moore Assessment Profile (MAP). Eighteen of the factors had sufficiently high loading items to be interpretable.

The data analyses of this study suggest that science teacher needs can be categorized into eighteen general areas. In addition, the results indicate that in terms of interpretability the factor analytic procedure is most satisfactory in identifying the needs of science teachers.

The factor analytic procedure offers an approach which would enable the assessment of the effect on science teacher needs of other relevant variables such as school level, grade level, science discipline, sex, and experience.

Of equal interest for future research is the extent to which scores on the factors identified in this study can be used to determine the high priority science needs of elementary teachers, junior high teachers, and senior high science teachers.

VALIDATING SCIENCE TEACHING COMPETENCIES
USING THE DELPHI METHOD

Dean R. Brown
Colorado State University
Fort Collins, Colorado 80521

and

Ronald D. Simpson
North Carolina State University
Raleigh, North Carolina 27607

In 1973 the Ad Hoc Committee on Education of Teachers of Science, sponsored by the National Science Teachers Association, produced a list of 23 basic competencies for teaching secondary school science. During the fall of 1974 and winter of 1975, investigators in this study attempted to validate these competencies by utilizing the Delphi method with panels of "experts" in Colorado and Georgia. The Delphi method was originally used as a forecasting device but has since been used as a technique for gaining consensus among small panels of carefully selected experts.

In this study 30-person panels were established in both Colorado and Georgia. The panel members were selected on the basis of their contributions and leadership in science education. Each panel consisted of five junior high school science teachers, five senior high school science teachers, five science coordinators or supervisors, five secondary school principals or school system superintendents, five college science instructors, and five university science educators.

Using a slight modification of the Delphi method, data from two rounds were collected and analyzed for the following:

1. Item means for each science teaching competency
2. Standard deviations for each competency item
3. Repeated measures analysis of variance
4. Factor analysis
5. Study of additional items added by both panels

Panel members were asked to rank each item on the basis of the following scale: (1) very important, (2) important, (3) makes no difference, (4) unimportant, and (5) very unimportant.

Based on scores from the combined panel on the second round, the 23 competencies ranged from 1.18 ("Be able to evaluate your own classroom behavior or to secure such evaluation from others in order to make any appropriate changes in teaching.") to 2.20 ("Be able to identify and complete all necessary actions with science clubs, fairs, assemblies, and talent searches.")

Standard deviations were calculated for all items after each round. Analysis indicated that with both panels, standard deviations for all items were lower for the second round than for the first round. During Round Two, all panel members were informed of group responses to Round One, reminded of their own responses, and given opportunities to change their responses. These data indicated that agreement among both panels was higher during their response to the various items on Round Two.

A repeated measures analysis of variance revealed no significant differences between panels or among the different types of panel members (i.e., science supervisors, college instructors, junior high school teachers). It had been hypothesized that some panel types would view certain of the teaching competencies with more or less value than other panel types: for example, a junior high school science teacher might rank "ability to maintain classroom control" higher than would a college science instructor. These data did not substantiate this notion. Using item responses from the combined panel from Round Two, the 23 basic science teaching competencies were factor analyzed and rotated by the Varimax procedure for 3, 5, 7, and 9 factors. Analysis of the rotated data produced clusters somewhat different from the hypothetical factors of the investigators. It had been hypothesized that factor analysis would verify that items were perceived by panel members in categories such as planning skills, instructional skills, evaluational skills, or other skills. One reason for this not occurring was that many of the items produced by the NSTA panel contained more than that one discrete competency. It appears that before basic science teaching competencies can be validated and factor analyzed, they should be written with more specificity than were the competencies studied in this investigation.

Finally, this investigation produced competencies that both panels deemed necessary in addition to the 23 produced by the NSTA panel. Members of the Colorado panel produced 11 additional competencies while Georgia panelists produced 9. Additional items by both panels appeared to be more "student oriented" than the items written by the NSTA panel. Several respondents felt that some of the 23 NSTA competencies seemed "traditional."

Data from this study indicated that all 23 NSTA competencies were viewed by expert panels from Colorado and Georgia as "very important" or "important." Data from Round Two exhibited greater agreement among members on both panels. Analysis of variance revealed no significant difference between panels or among types of panel members. After viewing data from a factor analysis, investigators in this study concluded that most of the 23 items produced by the NSTA panel do not represent single competencies that can be easily categorized. Rather, it appeared that many items contained multiple skills and could be classified in more than one way. Additional competencies produced by the Georgia and Colorado panels indicated a tendency to focus more on students, the learning process and attitudes when compared to the NSTA list of competencies. The Delphi method, or modified versions of the method, appear as a plausible means for gaining consensus among science educators regarding what are considered fundamental skills to be exhibited by science teachers.

THE INVESTIGATION OF ATTITUDE CHANGES OF ELEMENTARY PRESERVICE TEACHERS AND CLASSROOM TEACHERS INVOLVED IN A COMPETENCY-BASED, REALITY-ORIENTED SCIENCE METHODS COURSE

Martha K. Piper
University of Houston
Houston, Texas 77004

In a previous investigation with elementary teachers (Piper, 1973), changes in attitudes toward teaching science moved in a positive direction following an inservice program designed to give teachers the same experiences they would be expected to give students. As attitudes toward teaching science moved in a positive direction, the number of science activities in the classroom increased. If the attitudes of inservice teachers can be changed to move in a positive direction, perhaps the attitudes of preservice elementary teachers can similarly be changed. Preservice elementary teachers, whose attitudes toward teaching science move in a positive direction, may indicate an increase in science activities being taught after entering the teaching profession.

Three questions were asked in this study:

1. Do attitudes of preservice elementary teachers change toward teaching science in a positive direction during and following a competency-based, reality-oriented science methods course?
2. Do attitudes of elementary classroom teachers change toward teaching science in a positive direction following observation of science activities in their classroom taught by preservice elementary students?
3. If attitudes of preservice elementary teachers change in a positive direction during a competency-based, reality-oriented science methods course, will these attitudes toward teaching science remain positive over an extended period of time, and, if so, will there be an indication of science being taught?

Thirty-six (36) students enrolled in an elementary science methods course were randomly selected and given an instrument using Osgood's (1957) semantic differential approach the first week of class, the sixth week on campus prior to field experiences, and the thirteenth week following field experiences. The elementary teachers who had observed the university students teaching in their classrooms were given the semantic differential prior to the students teaching and following the students teaching in their classrooms.

A semantic differential instrument uses a bipolar set of adjectives to determine the perception of meaning that an individual associates with a concept (protocol). Five protocols were used to test the change in attitudes:

1. Science in High School
2. Science as Remembered in Elementary School
3. Science Methods Course
4. Science in the News
5. Teaching Science to Children.

A one-way analysis of variance repeated measures was used to analyze the data.

At the end of five weeks of on-campus activities, the university students changed their attitudes in a negative direction toward "Science in High School" and "Science as Remembered in Elementary School" but changed their attitudes in a positive direction toward "Teaching Science to Children" and "Science Methods." Following the reality experiences with children in the field, attitudes toward "Teaching Science to Children" and "Science Methods Courses" were even more positive than prior to field experiences.

The attitudes of classroom teachers who had university students teach science activities in their classrooms also changed in a negative direction toward "Science in High School" and in a positive direction toward "Teaching Science to Children."

The data of this study indicate that preservice teachers' attitudes toward teaching science can be changed in a positive direction. Inservice teachers' attitudes with preservice teachers can also be changed in a positive direction toward teaching science.

Another significance of the study is the continuation of the positive attitudes toward teaching science over a period of time and the indication of science being taught in the classroom.

Piper, Martha K. "The Development and Evaluation of Televised Science Inservice Program," accepted for publication, Journal of Research in Science Teaching, 1976.

Osgood, C. E., G. J. Suci, and P. H. Tannenbaum. The Measurement of Meaning. Urbana, Illinois: The University Press, 1957.

ASSESSMENT OF THE EFFECTS OF THE COMPETENCY BASED TEACHER EDUCATION EXPERIENCE ON THE ACQUISITION OF A TEACHING MODEL

David H. May
The University of Georgia
Athens, Georgia 30602

and

Frank E. Crawley
The University of Texas at Austin
Austin, Texas 78712

One characteristic shared by competency based teacher education (CBTE) programs is a series of intensive and extensive in-school experiences. Elementary education majors at The University of Georgia in CBTE are placed in schools during four quarters of their junior and senior years. Duration of the field experience and responsibilities for instruction increase as students become more confident and competent.

Since the classroom teacher serves as the model with whom the preservice teacher most closely associates during the in-school time, the teacher potentially exerts a tremendous amount of influence on each student's developing model of teaching. This study sought to develop an instrument capable of assessing the effect of the classroom teacher's model of teaching upon the model acquired by the student.

An instrument was designed which contained statements grouped into one of three categories depending upon the particular skill in question. These skills were instructional, interpersonal, and managerial in nature. Instructional skills included classroom knowledge, instructional purposes, design of activities and locus of control. Decision making and enforcement were the areas of concern for management skills. In the area of interpersonal skills two statements were written, one probing the emphasis placed on the teacher-student relationship; the other, the extent to which the teacher takes on the role of an authority figure when opinions are in conflict. A total of eight statements formed the instrument used to examine a person's teaching model. A Likert-type scale was used for indicating the extent to which an individual's model was teacher, class, or student-centered.

Data were gathered from Level I interns, student teachers, and cooperating teachers during the Spring Quarter, 1975, at The University of Georgia. Pre- and post-data were obtained from Level I interns; a single sampling of responses was collected from student teachers and cooperating teachers. A correlational analysis was conducted which examined intra- and inter-group agreements.

Numerous findings were made which indicate that the instrument was sensitive enough to measure change if, in fact, change occurred. Among these results were:

1. Level I interns did not significantly change their instructional or management models; significant change was noted in their interpersonal models of teaching.

2. Student teachers view the relationship between instructional and interpersonal models of teaching as similar whereas Level I interns see them as unrelated. Cooperating teachers were uncertain as to the relationship between the two teaching models.

3. Student teachers and cooperating teachers express similar views regarding the relationship between management-interpersonal models and instructional-management models of teaching. The two groups were polarized in their views regarding the relationship between interpersonal and management models of teaching. Student teachers viewed the two models as one and the same while cooperating teachers saw them as differing significantly from each other.

The observational experience gained by Level I interns has a significant effect upon their interpersonal model of the teaching experience. Neither their instructional nor management model undergoes significant change.

Level I interns and student teachers differ in their teaching models only with regard to the relationship between instructional and interpersonal models. Student teachers view the two as consistent with one another whereas their inexperienced counterparts see them as differing. This offers rather strong evidence in support of the in-school experience.

Student teachers encounter cooperating teachers who view management and interpersonal relations to be separate entities. Though student teachers may possess consistent similar views regarding the two, this may be subjected to change after a few years of teaching experience. The management-interpersonal model similarity represents the only occasion where differences were expressed between the two groups.

CONCURRENT SESSIONS II

Session IIA - Symposium: "Matching Experiences to Learner Needs"

Presiding: Marcia C. Linn, University of California, Berkeley, California 94720.

"Providing Educational Experiences Tailored to the Needs of Individual Learners"

Marcia C. Linn
University of California
Berkeley, California 94720

Herbert D. Thier
University of California
Berkeley, California 94720

Benjamin Chen
University of California
Berkeley, California 94720

Robert C. Knott
University of California
Berkeley, California 94720

Dennis Schatz
University of California
Berkeley, California 94720

PROVIDING EDUCATIONAL EXPERIENCES TAILORED TO THE NEEDS OF INDIVIDUAL LEARNERS

Marcia C. Linn
University of California
Berkeley, California 94720

Herbert D. Thier
University of California
Berkeley, California 94720

Benjamin Chen
University of California
Berkeley, California 94720

Robert C. Knott
University of California
Berkeley, California 94720

Dennis Schatz
University of California
Berkeley, California 94720

Educators have frequently proposed that learning is most likely to take place when the instructional situation is closely matched with the learner's abilities and interests. Many possible methods for achieving this situation have been tried. These include computer-assisted instruction, self-paced learning, individually prescribed instruction, etc. Several recent projects aimed at 10 to 15 year olds have developed and evaluated a new approach to providing for the individual learner.

Essentially, we have taken a new approach to providing personalized experiences. Individual activities have been developed that can be used by a variety of learners, at various levels of sophistication, and in any order. In the Outdoor Biology program the leader is encouraged to select the activity and the users are encouraged to decide when and how to participate. The Science Enrichment Center program and the visually impaired program rely on the user to choose both the sequence and the activities he wishes to experience. The science intervention project of the enrichment center program involves some leader selection and some user selection. These personalized or individualized programs are being developed, tested, and tried to determine the effects of free choice on user and leader. Brief summaries of each of the four projects follow.

The Science Enrichment Center: Personalized Science Instruction

Marcia C. Linn and Herbert D. Thier

The Personalized Science Instruction project has been developing approaches for providing science experiences for middle school children. Our goal has been to determine the conditions which will lead children to choose activities relevant to their interests and to provide a situation where they can work at their own intellectual level. These activities lead the child through an activity with a given set of materials and then provide several "challenges" that can be solved using the same materials. No directions are provided for these challenges. Over 40 activities in this format were developed.

Two important questions emerged. The first concerned evaluation of whether students were working at their own intellectual level. We have explored some answers to this question. Data relating the intellectual level of student reports to pretest and posttest scores will be presented. Other possible methods for evaluating student choices in an activity-oriented program will be discussed.

The second question concerns the role of the leader in a personalized activity centered program. The many possible approaches and the results of several different trials will be described and discussed.

Intervention Plus Enrichment: Serving the Needs of Individuals

Benjamin Chen

The basic objective of this study, which is part of the Science Enrichment Center Program, was to build into an individualized science program a set of interventions to promote upper-elementary children's ability to control variables.

The concept of controlling variables is a fundamental one according to Piaget. Its development is spontaneous but requires interaction with the environment. A program constructed solely on the basis of self-discovery has some limitations because students fail to perceive the applicability of prior successful solutions to other problems. When introduced to a series of science experiments, students frequently approach each one as totally new and different from the others. A set of interventions was developed and tried out in order to demonstrate methodological similarity between experiments. The strategies of interviewing and types of interaction between the interviewer and students and between students themselves, will be discussed. The approach was found to be effective in as much as subjects in the program improved significantly from pretest to posttest relative to a control group.

Outdoor Biology Instructional Strategies: Personal Success in the Choice Environment

Robert C. Knott

Outdoor Biology Instructional Strategies (OBIS) is developing both independent and sequential activities to promote the understanding of ecological relationships by youngsters from 10 to 15 years of age.

OBIS activities are primarily oriented toward community-sponsored youth organizations. The activities introduce basic concepts of ecology in ways that are palatable and exciting for youngsters.

The OBIS development process is one of devising a strategy, trying it out, then modifying it. Rather than determining a single sequence of learning activities leading to specific concepts, the OBIS staff is identifying and testing a variety of alternative strategies and techniques for environmental study. OBIS plans flexible units involving multiple entrance and exit points. Events and activities from other disciplines such as the physical and social sciences, art, recreation, and psychology are often used as interest-seducing "entrance activities" leading to the understanding of ecological problems.

Individualized Science Materials for the Visually Handicapped

Dennis Schatz

This project has developed over 20 discovery and materials-centered science activities for visually-impaired children. The materials and activities augment both the standard and innovative science curricula in current use with upper-elementary children throughout the United States by providing a wealth of interactive experiences for visually-impaired children in grades four through eight.

These activities are designed to satisfy two important needs of the students and teachers of the visually-impaired:

1. The need for materials to enhance the development of the visually-impaired student's logical reasoning ability;

2. The need for activities which match the individual abilities of the visually-impaired student, dictated by the nature of each student's cognitive style, verbal and manipulative skills, and attention span.

These materials have undergone extensive formative evaluation in local schools. This evaluation has resulted in a number of revisions and recommendations which will be described. In particular, the effectiveness of these materials with a variety of learners from many different backgrounds will be discussed.

CONCURRENT SESSIONS II

Session IIB - Training Session: "Concept Mapping" - Part II

Presiding: Joseph D. Novak, Cornell University, Ithaca, New York 14853.

Joseph D. Novak, James H. Stewart, and Richard M. Rowell

Cornell University, Ithaca, New York 14853.

CONCURRENT SESSIONS II

Session IIC - Contributed Papers: "Evaluation Studies"

Presiding:	Jerrold Maben, Herbert H. Lehman College, City University of New York, Bronx, New York 10468

1. "The Effects of Various Formative Evaluation Procedures on Instructional Material Revision in a Large Scale Individualized Science Curriculum Development Project." Jerome L. Ciesla, Florida State University, Tallahassee, Florida 32301.
2. "The Developing and Field Testing of an Instrument Using the Planetarium to Evaluate the Attainment of the Concept of Annual Motion." Robert R. Hayward, Fernbank Science Center, Atlanta, Georgia 30307.
3. "A Comparative Study of a Team Versus a Non-Team Teaching Approach in High School Biology." William J. Monaco, DuBois Area High School, DuBois, Pennsylvania 15801 and Michael Szabo, Pennsylvania State University, University Park, Pennsylvania 16802.
4. "Science Education in the Affective Domain: The Effect of a Self-Awareness Treatment on Career Choice of Talented High School Women." Walter S. Smith, University of Kansas, Lawrence, Kansas 66045.
5. "An Analysis of Science Teacher Education Graduates From Three State Universities Currently Employed Full-Time in Nonacademic Positions." Lynn W. Glass, Iowa State University, Ames, Iowa 50010.

THE EFFECTS OF VARIOUS FORMATIVE EVALUATION PROCEDURES ON INSTRUCTIONAL MATERIAL REVISION IN A LARGE SCALE INDIVIDUALIZED SCIENCE CURRICULUM DEVELOPMENT PROJECT

Jerome L. Ciesla
Florida State University
Tallahassee, Florida 32301

The purpose of this study was to determine which types of feedback information had the most influence on the revisions of instructional materials performed by writers in an individualized science curriculum development project.

Educational researchers involved in the formative evaluation of instructional materials are typically faced with the problem of trying to collect information that will be relevant to those persons who will use this information to improve instructional products. This paper will describe a large number of formative evaluative procedures used in the development of individualized science curriculum materials and examine the comparative influence that these procedures had on the users of these various pieces of feedback information. The various types of feedback that are described and evaluated in the paper include:

1. The revisors' own visits to classes using the trial materials.
2. Reviews of the materials made by "content experts."
3. Suggestions made to revisors by other writers.
4. Suggestions made to revisors by the Project Director or Associate Directors.
5. Audiotaped comments from teachers who used the trial materials.
6. Comments written by teachers in trial edition booklets.
7. Teachers' written responses to feedback questionnaire items.
8. Students' responses to feedback questionnaire items.
9. Students' test results.
10. The revisors' examination of copies of booklets used by students.

Each of the Individualized Science Instructional System (ISIS) Project Staff members, whose job it was to revise minicourse drafts produced and field-tested by the ISIS project, participated in an evaluation of the various types of feedback information that may have influenced their revisions of ISIS minicourses. These minicourse revisors were given a randomly ordered list of different types of feedback available to them. Independently, they rank ordered these items to show the comparative influence the items had on their actual revision of minicourse materials.

The resultant rank orderings from each of the seven participants were analyzed in terms of the importance placed on each of the ten feedback items by these revisors.

Of the ten types of feedback information available to these instructional material revisors, verbal (audiotaped) feedback from teachers was rated as the most influential type of feedback by nearly all of the subjects in this study. In fact, three different types of feedback from teachers were among the four types of feedback that received the highest ratings from these subjects in terms of the influence these types of feedback had on their revision tasks.

Different types of feedback, which involved information obtained from students who used the instructional materials, received the lowest ratings from these subjects. This is not to say that feedback from students did not influence these writers' minicourse revisions, but that feedback from teachers had a much greater influence than feedback from students.

In addition, informal and verbal, (i.e., non-quantitative) feedback was rated as being more influential than feedback data that was more formal and less verbal, (i.e., quantitative).

THE DEVELOPING AND FIELD TESTING OF AN INSTRUMENT USING THE PLANETARIUM TO EVALUATE THE ATTAINMENT OF THE CONCEPT OF ANNUAL MOTION

Robert R. Hayward
Fernbank Science Center
Atlanta, Georgia 30307

The major problem of this study was the development of an instrument, the Planetarium Test on Annual Motions (PTAM), that would use an observational format in the planetarium as a reasonable substitute for the real sky to evaluate the attainment of instructional objectives related to selected concepts on the annual motions of the sun, moon, and planets. The instrument was designed to evaluate student performance on 17 objectives, 3 processes of science, and 3 intellectual skills. Such an instrument could be used in evaluation of student performance under the real sky in investigations of a variety of teaching methods, techniques, and equipment.

Thirteen concepts on annual motions were developed. Seventeen behavioral objectives congruent with the concepts were developed and two items written for each objective. Three independent juries assisted in the evaluation, validation, and revision of these materials and the placement of each objective into a matrix of three processes of science and three intellectual skills. A series of four pilot studies and a field test were undertaken using sixth grade DeKalb County, Georgia, students. In the field test, 471 students were randomly assigned to three groups which received, respectively, a planetarium program, a similar classroom program, and no instruction (control). All groups were tested with the PTAM.

A final item analysis was undertaken using the field test data. Distractors and several indices were evaluated, and both norm and criterion-referenced reliabilities calculated. A final administration of the PTAM with follow-up interviews was used to help establish content validity of the objectives.

Field test results were obtained from proportional percentages analysis and the Newman-Keuls Test used to evaluate attainment of instructional criteria. Analysis of variance for unweighted means and the Newman-Keuls Test were used to evaluate means. All tests for significance were made at the .05 level.

Final item analysis showed 23 items met all of 4 criteria. Average item difficulty was 47 percent correct, with extremes at 20 percent and 77 percent. Livingston criterion-referenced reliability for a criterion of 20 (60 percent) was .85. Kuder-Richardson Formula 20 reliability was .66.

A reliability 34-item instrument was developed that could be used to evaluate student understanding of 13 observational concepts. Both the planetarium and school classroom treatments used in the field test produced general gains in achievement more than mastery of concepts. However, the planetarium was significantly superior to the classroom on many mean and criterion scores for content objectives and, in general, the planetarium instruction fared well on objectives requiring evaluation of observational relationships and higher skills using these observations.

The PTAM as developed in this study can be used to evaluate any teaching method or technique whose content objectives are the same as those observational objectives evaluated by the PTAM. It can also be used to evaluate the use of certain skills and processes. Thus, it can be used as the evaluative instrument in a research design to investigate a large variety of questions in science, astronomy, and planetarium education.

A COMPARATIVE STUDY OF A TEAM VERSUS A NON-TEAM TEACHING APPROACH IN HIGH SCHOOL BIOLOGY

William J. Monaco
DuBois Area High School
DuBois, Pennsylvania 15801

and

Michael Szabo
Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of this study was to obtain empirical data for the evaluation of a team approach for academic biology students.

The sample consisted of 147 sophomore students selected on the basis of ranked science sub-scores on the Stanford Achievement Tests. Each of the six sections was randomly assigned to control or treatment groups. A comparison of control and treatment groups' mean SAT science sub-scores was not significant.

The team consisted of three male biology instructors with a minimum of four years experience each. Each member taught a control group for an entire year. After an Introductory session of nine weeks, team members began teaching their speciality (botany, genetics, or microbiology) to the treatment groups. Students in the treatment groups worked with a different team instructor each nine weeks.

The team conferred daily and wrote brief descriptions of the topic covered that day in class. These notes were employed as a guide for instructing the control groups. The textbook was the First Edition, BSCS Inquiry Into Life. Laboratory work was emphasized in the botany and microbiology specialities. There were no large group lectures.

The criteria used in this study consisted of T-scores from five separate objective tests. Subject area tests consisted of 45 multiple choice questions. The final examination contained 40 questions.

Four of the tests were composites of questions from standardized BSCS Blue and Yellow exams as well as the Nelson Biology forms "E" and "F." Each member selected those items he felt were appropriate for the Introduction and his speciality. After eliminating duplications, each instructor chose 45 items to be used as an achievement measure for his speciality. The tests were administered the last day of each nine week period. The botany test included eight items which were teacher constructed for this study as no suitable standardized questions could be found to evaluate some of the topics in botany.

The other criterion measure was the BSCS Processes of Science Test (POST). This was a 40 item multiple choice test given at the end of the year.

K.-R. 20 reliability coefficients on the examination ranged from 0.66 to 0.78.

The experimental design was a 2 x 3 x 5 factorial analysis of variance with intact class sections randomly assigned to experimental or control groups. Variables included two groups, three instructors, and five content areas. In addition, 27 students were randomly dropped from the study to meet the requirements for equal cell size in the computer program, leaving 20 pupils per section.

The following seven conclusions were drawn: (1) Academic biology students acquire more biology subject matter knowledge when they are instructed by a team rather than a single instructor. (2) There were significant differences among each of the instructors relative to student achievement in biology. (3) Significant interactions were found to exist between the instructors and their groups. (4) There appeared to be no significant differences among content areas relative to student achievement in biology. No significant interactions were observed between (5) instructors and content, (6) groups and content, or (7) instructors, groups, and content.

SCIENCE EDUCATION IN THE AFFECTIVE DOMAIN: THE EFFECT OF A SELF-AWARENESS TREATMENT ON CAREER CHOICE OF TALENTED HIGH SCHOOL WOMEN

Walter S. Smith
University of Kansas
Lawrence, Kansas 66045

Studied was the effect of an instructional treatment designed to encourage highly qualified high school senior women to pursue male-dominated science careers such as physician or engineer. During the instructional treatment subjects considered their capabilities and aspirations in relation to possible science careers and also analyzed their decision-making process. Subjects had scored in approximately the top 15 percent on the ACT mathematics and science tests and had taken two years of science and three years of mathematics in high school. The study's second purpose was to ascertain what kinds of barriers (e.g., role conflict, inadequate support in career) highly qualified high school women thought had affected their career choices.

A posttest-only design was used to compare the treatment group with two control groups. One control group, comparable to the treatment group, had graduated from high school one year earlier than the treatment group women. The second control group was composed of qualified women who did not choose to take part in the instructional treatment. Random assignment to groups was impossible, due to the nature of the treatment. Groups were compared for their (1) career choice, (2) response to a role conflict problem, and (3) barriers affecting career choice.

The posttest, given at the end of the subjects' first college semester, asked subjects to indicate their career choice and their proposed solution to a problem where the roles of parent, spouse, and professional career person conflicted. It was hypothesized that, in comparison to the control groups members, the treatment group members would more often choose male-dominated careers and resolve the role conflict through compromising the roles, rather than excluding the professional career role as incompatible with the parent and spouse roles.

In order to ascertain what barriers may have affected career choice, the posttest presented the subjects a list of possible barriers (e.g., "pursuing a professional science career would conflict with my responsibilities to raise my children."). For each barrier, subjects indicated whether they possessed that feeling and, if so, whether that feeling had affected their career choice.

Conclusions about the groups' career choice and resolution of role conflict cannot be formulated until after the December 1975 administration of the posttest to the treatment and second control group. However, based on the posttest given to the first control group (December 1974), we concluded that for highly qualified high school senior women, the primary barrier to their pursuing male-dominated science careers was their perceptions of a conflict among the roles of parent, spouse, and professional science career person.

There is current concern that some highly qualified people (particularly women) have been limited in career choice, leading to a waste of talent for society and problems of dissatisfaction among talented women. Instructional treatments to alleviate the problem have been aimed at remediation (e.g., special mathematics instruction), career awareness (e.g., "Career Day"), or self-awareness. The present study should allow conclusions about the effect of a self-awareness treatment on career choice.

AN ANALYSIS OF SCIENCE TEACHER EDUCATION GRADUATES FROM THREE STATE UNIVERSITIES CURRENTLY EMPLOYED FULL-TIME IN NONACADEMIC POSITIONS

Lynn W. Glass
Iowa State University
Ames, Iowa 50010

Seldom do institutions of higher education conduct follow-up studies of their graduates in sufficient detail to permit them to analyze the strengths and weaknesses of the institutions' curriculum in terms of the graduates' current employment. The study reported herein was designed to analyze the responses of 173 science teacher graduates from the 1964-1965, 1969-1970, and 1973-1974 school years. All respondents received their baccalaureate during one of the above study years from either Iowa State University, The University of Iowa or the University of Northern Iowa.

The first objective of the study was to determine the career profiles of all science teacher graduates during the three study years from the Iowa Regents Institutions. A questionnaire was mailed to each graduate and responses (75 percent return, N = 173) were categorized into one of nine different career profile patterns. An examination of the end point of each career pattern indicated that: 54.3 percent of the graduates currently are employed full-time in an academic position, 30.6 percent of the graduates currently are employed full-time in nonacademic positions (positions other than teaching, administration or academic support positions in an elementary-secondary or collegiate institutions), 9.8 percent of the graduates currently are employed part-time, and 5.2 percent of the graduates have never been employed since receiving their science teaching certificate.

The second major objective of the study was to collect information on the members of the study sample that currently were using their science teacher preparation for full-time nonacademic employment. These graduates held full-time occupations in eight of the nine major occupational divisions of the Dictionary of Occupational Trades.

Information from the full-time nonacademically employed graduates was collected via a 69 item questionnaire which sought to answer the following four questions:

1. What factors led each science teacher graduate of one, five, and ten years ago to accept employment in nonacademic fields?

2. What skills and competencies obtained in the science teacher education program by graduates of one, five, and ten years ago were used to secure and to function in employment in nonacademic fields?

3. What skills and competencies needed in their current occupation and related to the science teacher education program do graduates of one, five, and ten years ago wish they had?

4. *What experiences in the science teacher education program have been useful in preparing graduates of one, five, and ten years ago for their personal and civic lives?*

Chi Square tests of significance were used on most of the 69 items in the questionnaire to identify those factors, skills, competencies, and experiences judged to be important by the respondents in terms of their current nonacademic positions.

Information gathered in this study is being utilized as input into the science teacher education curriculum development process in each of the three Regents Institutions. Since the institutions are diverse in their nature (a land-grant institution, a state university, and a former teachers' college) the data should be of value to teacher educators in other institutions of higher education who are concerned about their science teacher preparation curriculum in terms of graduates who find the science teacher preparation program a liberal arts option with a vocational choice.

CONCURRENT SESSIONS II

Session IID - Contributed Papers: "Preservice Teacher Education"

Presiding: Marjorie S. Muehlke, University of Pittsburgh, Pittsburgh, Pennsylvania 15213.

1. "The Effects of an Activity-Centered Elementary Education Science Methods Course on the Attitudes of Preservice Teachers." Barbara M. Strawitz, Louisiana State University, Baton Rouge, Louisiana 70803.

2. "A Study of Relationships of Science Attitudes, Achievement and Self-Concept of Pre-Service Teachers." Luis A. Martinez-Perez and Richard L. Campbell, Florida International University, Miami, Florida 33199.

3. "The Effects of Microteaching With Videotaping on the Teaching Strategies of Pre-Service Secondary Science Teachers." Russell H. Yeany, Jr., The University of Georgia, Athens, Georgia 30602.

4. "Structural Compatibility Inventory (SCI)--An Instrument for Assessing Learning Structure Condition." Frank E. Crawley, The University of Texas at Austin, Austin, Texas 78712 and John W. Shrum, The University of Georgia, Athens, Georgia 30602.

5. "A Comparison of Two Laboratory Methods in the Teaching of Science For Elementary Teachers: Simulated Experimentation Versus Conventional Experimentation." Melvin O. Smith, Norfolk State College, Norfolk, Virginia 23504.

THE EFFECTS OF AN ACTIVITY-CENTERED ELEMENTARY EDUCATION SCIENCE METHODS COURSE ON THE ATTITUDES OF PRESERVICE TEACHERS

Barbara M. Strawitz
Louisiana State University
Baton Rouge, Louisiana 70803

The purpose of this study was to assess the effects of an undergraduate science methods course on student attitudes and to determine if the effects were a function of student belief systems. There is theoretical and empirical support for the idea that the attitudes of teachers influence their behaviors and that attitude acquisition is affected by belief systems.

The subjects were 82 elementary education majors enrolled in three sections of the science methods course at Louisiana State University during the 1975 Spring Semester. Forty-four elementary education majors not enrolled in the course served as a comparison group. Students in the treatment group spent most of their time presenting and participating in science activities which they selected from ESS, SCIS, and SAPA materials. The science activities served as the focal point for everything that was discussed in the course. Students were encouraged to develop individual teaching styles appropriate for various goals of instruction, consider feedback from the instructor and peers, and formulate their own concepts about teaching strategies and roles appropriate for the teaching of elementary school science. Students in the comparison group discussed topics such as planning for effective teaching, individualizing instruction, and evaluating instruction.

Scores on an attitude assessment inventory developed by Ronald Good were used as a premeasure at the beginning of the semester and as a postmeasure approximately 14 weeks later. Scores on Form E of the Dogmatism Scale developed by Milton Rokeach were used as a measure of the belief systems of the students. The dependent variable in the study was teacher attitude, and the independent variables were the method of instruction and teacher dogmatism.

A 2 x 3 least squares analysis of covariance using pretest attitude scores as the covariable was used to test the effects of the treatment on teacher attitudes and interaction effects between the treatment and high, medium, and low levels of teacher dogmatism. Statistically significant treatment effects ($p < .05$) were found for 13 of 30 statements on the attitude inventory. Statistically significant aptitude x treatment interaction effects ($p < .05$) were found for 2 of 30 statements.

These findings suggest that the instructional method was very effective in changing the attitudes of students about teaching science in the elementary school in a manner consistent with the desired outcomes of the course. It appears that attitude changes due to the treatment were for the most part unrelated to the belief systems of the students.

This study is significant if one accepts that the attitudes of teachers affects their behaviors and the kinds of climates they create in their classrooms. It demonstrates that certain instructional strategies can be effective in fostering desirable attitude changes even in students who are resistant to change.

A STUDY OF RELATIONSHIPS OF SCIENCE ATTITUDES,
ACHIEVEMENT AND SELF-CONCEPT OF PRE-SERVICE TEACHERS

Luis A. Martinez-Perez

and

Richard L. Campbell
Florida International University
Miami, Florida 33199

A recent survey conducted by the National Assessment of Educational Progress (1975) showed that science knowledge at all levels of education has declined. This finding could possibly be explained by Blackwood's survey (1964), which indicated that one of the barriers to effective science teaching is a lack of interest in science by teachers. One possible way to correct this problem is to structure science methods courses to include activities that will foster positive attitudes toward science. Furthermore it may be prudent to examine self-concept, in addition to attitudes, as interacting variables affecting teacher's interest in science.

The purpose of this study was to test the hypothesis that there are positive correlations among 1) attitudes toward science, 2) self-concept, and 3) achievement of science process skills.

The 68 students who served as subjects were juniors and seniors enrolled in science methods courses in elementary education during the spring quarter of the 1974-75 school year. The science methods course combined science instruction with field-based experiences. Data were gathered at the end of the quarter.

The Moore and Sutman (1970) Scientific Attitude Inventory (SAI) was used to gather data on student attitudes. Post-test items were constructed based on the Basic Science Process Skills (BSPS) and the Integrated Science Process Skills (ISPS). Fitts' (1964) Tennessee Self-Concept Scale (TSCS) was used to gather data on self-concept. Data were analyzed by calculating Pearson's product-moment correlation coefficients.

Examination of correlation coefficients indicated that there were positive correlations between 1) basic science process skills and integrated science process skills ($p < .001$), 2) basic science process skills and attitudes toward science ($p < .001$), 3) basic science process skills and self-concept ($p < .004$), 4) integrated science process skills and attitudes toward science ($p < .001$), 5) integrated process skills and self-concept ($p < .001$), and 6) attitudes toward science and self-concept ($p < .001$).

The significance of this study lies in the fact that it is another attempt to support the assumption that there is a positive correlation between knowledge of science process skills and 1) self-concept and 2) attitudes toward science.

THE EFFECTS OF MICROTEACHING WITH VIDEOTAPING ON THE TEACHING STRATEGIES OF PRE-SERVICE SECONDARY SCIENCE TEACHERS

Russell H. Yeany, Jr.
University of Georgia
Athens, Georgia 30602

This study was designed to assess the effects of three treatment levels involving microteaching with videotape play back and strategy analyses on the teaching strategies selected by secondary science teaching methods students.

In order to measure the above effects, three intact groups of ten students each were randomly assigned to three treatment levels. All subjects taught a pre-treatment and a post-treatment peer group lesson. Both of these lessons were videotaped; the first to be used as part of the treatment and also as a concomitant variable in the data analysis; and, the second to be analyzed for any influence of treatment on the teaching strategies employed by the subjects. The treatment levels varied in the following manner:

> Level I - After the students in this group were taped while microteaching a self-selected and designed lesson to their peers, they were asked to schedule a personal and private viewing of the tape. No instructions were given in relation to what they should be looking for in the tapes except that they should be more concerned with the teaching act rather than the more cosmetic concerns of appearance, mannerisms and voice. After each student was taped and had an opportunity to view his pre-lesson, they were each taped in a post-lesson session.
>
> Level II - The only variance in the activities of this group when compared to Level I is that after the pre-lesson was taped, they received instruction in the use of the Teaching Strategies Observation Differential (TSOD) which they were required to use while viewing their pre-lesson in private. The coding sheets that resulted from these private viewings were collected but not discussed with the subjects.
>
> Level III - The subjects in this level received the same instruction in the use of the TSOD. The viewing procedures of the level differed from the others in that after the initial personal viewing by the subjects, they were required to schedule a viewing session with the instructor of the course in which the research was being conducted. During this session the strategies employed by the subjects were coded by both the instructor and the subject. No efforts were made to place a value judgment on the selection of strategies. The main task was to systematically define the type of strategy exhibited in the lesson.

Data on the dependent variable were collected by a trained rater. This rater used the TSOD to analyze the post-treatment tapes for the degree of directness/indirectness exhibited by each subject in their teaching style after treatment. The TSOD can be used to categorize teaching style on a continuum from expository/direct to inductive/indirect.

The data were analyzed through the use of an ANCOVA procedure. The degree of directness as measured by the TSOD on the pre-lesson wa used as the covariate in this analysis. The selection of ANCOVA and covarying on the pre-lesson data was done in order to remove any selection bias resulting from the use of intact groups and to increase the statistical power of the hypothesis testing. Also, in order to increase statistical power, an a priori decision was made to test all hypotheses at the .10 alpha level and identify level I as the control group for post hoc analyses.

Analyses of the data indicated that a significant difference existed among the three means $(p < .001)$. Post hoc comparisons using the Dunnett test showed differences between Level III and Level I (control) and Level II and Level I $(p < .01)$. Other pair-wise comparisons using the Newman-Keuls technique supported the above analysis and picked up a difference between Level I and Level II. Thus, one may conclude that the three group means were all different with the greatest influence of change being less than .05. The order of these differences showed the Level III subjects to use more indirect teaching strategies than Levels I and II and Level II subjects were more indirect than Level I.

These trends seem to indicate a cumulative effect of the treatment procedures. That is, if one wants to influence teaching strategies, having students systematically analyze micro-lesson will have a statistically significant but minimal impact, while providing non-biased interaction with an instructor after the systematic analysis will cause another full standard deviation shift in the same direction.

One of the implications of this research is that there may be certain advantages to individualized or self-paced teacher preparation programs. But let us not forget to build in opportunities for students to interact with the professors. The clarity and on-task guidance that can be provided may help maximize some of the outcomes.

STRUCTURAL COMPATIBILITY INVENTORY (SCI)--AN INSTRUMENT FOR ASSESSING LEARNING STRUCTURE CONDITION

Frank E. Crawley
The University of Texas at Austin
Austin, Texas 78712

and

John W. Shrum
The University of Georgia
Athens, Georgia 30602

Festinger's (1957) Theory of Cognitive Dissonance holds that it would be inconsistent for students to elect to study any course in which they were expected to learn in ways they don't prefer. A theoretical basis for associating negative course preference with an incompatible learning structure is presented by Osgood, Suci, and Tannenbaum (1957) in congruity theory. Recent research with students enrolled in introductory science courses at The University of Georgia tended to substantiate this claim. Results of this research have been submitted for publication. This report presents results of studies conducted to assess the stability over time of perceptions and preferences registered by students responding to the SCI instrument.

The Structural Compatibility Inventory (SCI) is an instrument designed to determine whether or not a student is learning in preferred ways. Course compatibility is investigated by comparing each student's perceived and preferred learning structure for that course in which he is enrolled. The SCI instrument contains a description of three instructional modes differing only with regard to the locus of control: teacher, class, or student. Students respond by indicating which of the three they perceive to be most descriptive of instruction and which they would prefer, based on their individual learning needs.

Participants were asked to respond to the instrument on two separate occasions, separated by a two-day interval of time. The stability of perception and preference responses was separately determined by computing the percentage of total participants for whom no change was indicated over the two-day period.

A broad spectrum of preservice secondary teachers was utilized for the purpose of investigating the stability aspect of student responses to the SCI instrument. Those teachers participating were enrolled in one of three courses: a science methods and general methods course offered at The University of Texas at Austin and a science methods course offered at The University of Georgia. All participants registered both their perceived and preferred learning structure for the course on two occasions, separated by a two-day interval of time.

Preliminary results have indicated that students' perceptions of a course's learning structure are quite stable. Preferences for a given learning structure condition, however, do not remain as stable over the same two-day interval. The lack of stability of student preferences was consistent with results of an earlier study conducted by Goldberg (1972).

Students within the same course possess widely differing perceptions of the degree of structure. These perceptions remain unaltered over a two-day time period. Preferences, on the other hand, differ among students and over time. Due to the nature of the content offered in introductory science courses, provisions for a variety of learning experiences incorporating a multipathway format are feasible. Such provisions offer students the opportunity to select those approaches which best meet their individual learning needs. Use of the SCI instrument enables an instructor to gather preliminary evidence regarding students' learning needs for his course.

A COMPARISON OF TWO LABORATORY METHODS IN THE TEACHING OF SCIENCE FOR ELEMENTARY TEACHERS:

SIMULATED EXPERIMENTATION VERSUS CONVENTIONAL EXPERIMENTATION

Melvin O. Smith
Norfolk State College
Norfolk, Virginia 23504

The central theme of many of the new science curricula is direct student involvement. Many science educators operate on the assumption that laboratory activities are fundamental to the achievement and progress of students enrolled in most science and science-related courses. This research effort focused on the laboratory component of science for elementary teachers classes. It compared the relative effectiveness of simulated experimentation which permitted students to collect data by non-manipulative means, and conventional experimentation which permitted students to collect data by the traditional manipulation of science materials and equipment.

A general objective of the research effort was to design and test a laboratory instructional method which would afford an alternate learning pathway and laboratory approach for students who enroll in science for elementary teachers courses. The comparative study addressed specific objectives which attempted to measure any significant difference in achievement with respect to: (1) reading, as measured by the Nelson-Denny Reading Test, (2) scientific facts and principles, as measured by the STEP, (3) attitudes, as measured by the Welch Science Process Inventory, and (4) methods and approaches of scientists, as measured by the Smith Appraisal of Methods and Process of the Scientist.

The research focused on the theory that learning in laboratory activities results, in part, from the mental calisthenics associated with the use,analysis and interpretation of data and not necessarily from the methods by which those data were obtained.

Two intact groups were used for the study. The groups were composed of prospective elementary and special education majors at Norfolk State College. The experimental group was the non-manipulative participants. The research was conducted over a 12-week period, and followed the pre test - post test design.

Data from test scores from the aforementioned evaluative instruments were used in a Covariance Analysis Program. The null hypothesis was stated and tested with the test scores from each instrument alternately serving as covariants.

Based on the data generated by testing the null hypothesis, simulated experimentation appeared to promote reading ability and the ability to apply the methods and processes of the scientist. There was no significant difference in achievement with respect to critical thinking and the mastery of science content.

Students can learn content, processes, and techniques of laboratory activities by either method. Simulated experimentation has a lower cost per student and requires less classroom time. It provides greater student and teacher options and brings to the classroom many experiments which were heretofore inaccessible because of cost, location, and other physical limitations.

CONCURRENT SESSIONS III

Session IIIA - Paper Set: "Theoretical Bases for Attitude Research"

Presiding: Emmett L. Wright, University of Maryland, College Park, Maryland 20742.

1. "Generating Theoretical Bases for Attitude Research in Science Education: The Learning Theory Approach." Robert L. Shrigley, The Pennsylvania State University, University Park, Pennsylvania 16802.
2. "Generating Theoretical Bases for Attitude Research in Science Education: The Dissonance Theory Approach." Joseph Riley, University of Delaware, Newark, Delaware 19711.
3. "Generating Theoretical Bases for Attitude Research in Science Education: The Functional Approach." Theodore Johnson, The Pennsylvania State University, University Park, Pennsylvania 16802.

GENERATING THEORETICAL BASES FOR ATTITUDE RESEARCH IN SCIENCE EDUCATION:

THE LEARNING THEORY APPROACH

Robert L. Shrigley
The Pennsylvania State University
University Park, Pennsylvania 16802

The concern of science educators for attitude modification is indicated by the many attitude studies reported in the literature. Attitude-related papers presented at the last annual NARST (1975) meeting was evidence of this concern. It seems valid to assume that attitude research is crucial to the future of science education, especially in the elementary schools of the nation where many teachers have less than a positive attitude toward science.

With the need for attitude research manifested and the existence of valid scales to measure the attitudes of teachers, there remains one missing component necessary for initiating experimental research in attitude modification. A close examination of the literature will reveal that little has been done to generate a theoretical rationale on which to base attitude research in science education.

Not to have a theory of attitude modification on which to build experimental research is to design studies on such global variables as lecture versus demonstration, or Methods Course A versus Methods Course B. If a significant difference in attitude change between such broad treatments does occur, the variables are so nebulous that one can only speculate as to the crucial variable, or combination of variables, responsible for the results.

The logical place to seek an initial base of operations is the literature of the social psychologist where research in attitude modification theory has been nurtured for decades. Wagner and Sherwood (1969) summarized four contemporary approaches to attitudinal research:

(1) the learning theory approach,
(2) the dissonance theory,
(3) the functional approach, and
(4) the perceptual theory.

For the purpose of this paper, only the first three approaches will be examined, primarily because a clear set of principles has not been established for the perceptual theory.

The purpose of this set of papers is to (1) examine the literature of the social psychologist supporting (a) the learning theory, (b) the dissonance theory, and (c) the functional approach; (2) make initial applications of the principles to science education; and, (3) generate a sampling of questions concerning teacher education that might be examined by research based on each theory.

Proponents of the learning theory approach suggest that attitude change is a form of learning achieved under the same stimulus-response conditions as other learnings (Wagner and Sherwood, 1969).

The learning theory approach to attitude change would seem to be a logical one for educators to examine when initiating the development of a paradigm for positive attitude change of teachers toward science. Central to the learning theory approach is the credibility of the communicator, a model supported by learning theorists who assume that attitude modification is a form of learning. The basic assumption to this theory is that the expertise and trustworthiness of the communicator affects attitude change of recipients toward the position advocated by the communicator. The communicator's primary mode of operation is verbal persuasion and the respondent's reward for learning is the act of agreement with the communicator.

Hovland (1953) and his associates at Yale have developed a four-part core to this approach in the statement: "Who (the communicator) says what (the communication) to whom (the recipients) with what affect (the response)?" Translated into the field of science education, the communicator for preservice teachers could be the science methods instructor with the school principal and science supervisor affecting the attitude of inservice teachers.

Presumably the communication would deal with the importance of the scientific enterprise in the lives of children living in a technological society. The recipients would be public school teachers, and, theoretically, the response would be a positive attitude toward science.

Preliminary research has been done on the first component, the communicator, where a survey of 287 preservice teachers from four midwestern colleges and universities by Shrigley (1974) implied that the more credible instructor of elementary school science methods course to be a former elementary teacher who continues to keep close liaison with science teaching in the public schools. In this study, professional writing did not seem to enhance the credibility of the instructor with preservice teachers.

Science educators need to examine all four parts of the credibility components of the learning theory approach. For example, should the communicator draw conclusions or let the respondents draw conclusions? Would emotional or rational appeals be more effective?

In dealing with the third and fourth components, should the recipients be encouraged to provide counter-arguments? Should teachers who are neutral or negative toward science be directed to play a positive verbal role? Could the mode of role playing so common in methods courses, where education majors play the role of the child in SAPA, SCIS, or ESS lessons, affect the attitude of the preservice teacher?

References cited are included in the last paper of this set by Theodore Johnson.

GENERATING THEORETICAL BASES FOR ATTITUDE RESEARCH IN SCIENCE EDUCATION:

THE DISSONANCE THEORY APPROACH

Joseph Riley
University of Delaware
Newark, Delaware 19711

Cognitive dissonance is concerned with what happens when the cognitions of a person are discrepant. This theory is based on the premise that discrepant cognitions create tension which the individual strives to reduce by making his cognitions more consistent. This tension is called cognitive dissonance. The effort employed toward consistency is termed dissonance reduction.

An example of cognitive dissonance is the attitude of a person who continues smoking, knowing that it is bad for his health. Dissonance reduction occurs in the form of rationalizations such as (a) the evidence against smoking isn't conclusive or (b) the enjoyment of smoking is worth the risk. By reducing the dissonance, consonance or consistency is achieved and continuing to smoke becomes consistent with the person's ideas about smoking. Dissonance could also be reduced if the person stopped smoking.

Assuming that an elementary teacher believes science to be an important part of every child's life, the same teacher fails to incorporate science into the child's daily schedule. Theoretically, these discrepant cognitions could create tension that the teacher might strive to reduce.

Dissonance reduction might occur in several ways. The rationalization for slighting science could be lack of equipment when, in reality, it is a fear or dislike for the scientific enterprise. Or, convinced that science is important, teachers could modify their attitude as evidenced by including science in the daily schedule.

One application of cognitive dissonance theory to science education is the provision of a theoretical framework for assisting in the interpretation of results of science attitude research. In an investigation of preservice elementary teachers' attitudes toward the teaching of science, Riley (1974) found that students who had a low science grade point average in college reflected a significantly more positive attitude on one of the measuring scales than did students who had a higher science grade point average. The scale measured attitude toward whether science teaching should be the guiding or facilitating of learning as opposed to information-giving. Students with low science grade point average reflected a significantly more positive attitude that a teacher should be a resource person rather than an information giver.

Interpretation in terms of cognitive dissonance theory suggests that cognitive dissonance was experienced by the low science grade point average students having to teach a subject that they had little knowledge or success in. Dissonance reduction was reflected in their positive acceptance of an attitude toward teaching which portrayed a teacher's role as one of guide or facilitator rather than a giver of information. Consonance was achieved with their acceptance of an attitude that one did not necessarily need a great deal of science knowledge to be a good science teacher.

Does the failure to teach science result in dissonance in the cognitions of elementary teachers? Are teachers convinced that the scientific enterprise will be important to today's child in the year 2000? Is there any way that knowledge about (1) the scientific enterprise; (2) science teaching; and (3) science content could help a teacher better organize an otherwise disorganized professional or personal environment?

References cited are included in the last paper of this set by Theodore Johnson.

GENERATING THEORETICAL BASES FOR
ATTITUDE RESEARCH IN SCIENCE EDUCATION:
THE FUNCTIONAL APPROACH

Theodore Johnson
The Pennsylvania State University
University Park, Pennsylvania 16802

The rationale for the functional approach to attitude change as designed by Katz and Stotland (1959) has four components. Man changes his attitude toward a psychological object:

(1) because his attitude change maximizes his reward and minimizes the possibilities for punishment. Here attitude change seems an instrumental function.

(2) When such a change is consistent with his own established value system.

(3) When knowledge gives meaning and consistency to an otherwise disorganized environment.

(4) When the change assists in the defense against certain ego-perceptions that are otherwise too uncomfortable to be known.

It is possible that elementary teachers are not adequately rewarded for teaching science. Teachers may realize reward or punishment from one or more of four groups: (1) administrators; (2) colleagues; (3) the community; or (4) children.

If administrators better legitimized science programs through provision of equipment and supplies, or, if colleagues provided each other moral support, or, if the community showed the concern for science that they display for the three R's, perhaps more science would be taught. Child support of the teacher might be adequate, however, they do not hold the purse strings.

In an initial study made by Shrigley (1975) where he asked teachers to respond to the single statement, "I will teach more science if/when . . . ," the responses sorted into seven categories:

1. More equipment, materials, space - 37%
2. More time - 16%
3. An organized science program designed for the school - 14%
4. I feel more qualified - 10%

5. Restraints of school officials are removed - 10%

6. Proper text is adopted - 8%

7. Miscellaneous - 8%

This preliminary study has many implications supporting the functional approach, especially Katz's instrumental component.

1. If teachers were rewarded with equipment, materials, peer support, and community support, would their attitude become more positive and science teaching more prominent in the daily schedule? (The instrumental function) -

2. Are their values inherent in elementary teachers that conflict with the scientific enterprise? (The value-expressive function)

3. Are pre-service and in-service science experiences failing to assist teachers in perceiving how science has the potential to bring order to a classroom and a child's environment? (knowledge function)

Hovland, C. I., I. L. Janis and H. H. Kelley. *Communication and Persuasion*. New Haven: Yale University Press, 1953.

Katz, D. and E. Stotland. "A Preliminary Statement to a Theory of Attitude Structure and Change." *Psychology, A Study of a Science Vol. 3*. New York: McGraw-Hill, 1959.

Riley, J. "The Effect of Science Process Training on Preservice Teacher Elementary Teachers' Process Skill Abilities, Understanding of Science, and Attitudes Toward Science and Science Teaching." Unpublished doctoral dissertation, University of Colorado, 1974.

Shrigley, R. L. "Credibility of the Communicator: A Paradigm for Attitude Change for Preservice Elementary Teachers Toward Science." A paper presented at the national meeting of the National Association for Research in Science Teaching, Chicago, Illinois, April 16-18, 1974.

Shrigley, R. L. Unpublished report, 1975.

Wagner, R. V. and J. J. Sherwood. *The Study of Attitude Change*. Belmont, California: Brooks/Cole Publishing Company, 1969.

CONCURRENT SESSIONS III

IIIB - Contributed Papers: "Inservice Teacher Education"

Presiding: John T. Wilson, University of Iowa, Iowa City, Iowa 52240.

1. "The Effects of Microteaching on Changing Inservice Elementary Teachers' Attitudes Toward Science Instruction." Harold H. Jaus, Purdue University, West Lafayette, Indiana 47907.

2. "The Effectiveness of Institutes for Changing the Philosophy of Teaching Elementary School Science." David R. Stronck, Washington State University, Pullman, Washington 99163.

3. "An Analysis of Science Teachers' Beliefs About Teacher Classroom Behavior." Willis J. Horak, University of Arizona, Tucson, Arizona 85721.

4. "A Research Based Rationale for Teacher Intervention in the Learning Process." Glenn Clark, Memorial University, St. John's, Newfoundland, Canada A1C 5S7 and John P. Smith, University of Washington, Seattle, Washington 98105.

THE EFFECTS OF MICROTEACHING ON CHANGING INSERVICE ELEMENTARY TEACHERS' ATTITUDES TOWARD SCIENCE INSTRUCTION

Harold H. Jaus
Purdue University
West Lafayette, Indiana 47907

Microteaching has been used for several years as a technique for developing skills deemed important for successful teaching. Many studies have found that microteaching can be effective in augmenting higher level inquiry skills, lesson pacing, pupil-teacher interaction, and non-verbal behaviors. On the other hand, no studies have shown a positive and significant effect of microteaching on changing teachers' attitudes toward teaching science as a process. The purpose of this study was to determine the effects of microteaching on changing inservice elementary teachers' attitudes toward teaching science as a process.

A control group of inservice elementary teachers (n = 31) received instruction in the basic and integrated science process skills via self-instructional pamphlets. An experimental group of inservice teachers (n = 33) received the same instruction plus process skill microteaching with elementary school children. These microteaching sessions consisted of teaching the science process skills two hours per day for ten days to groups of elementary school children. Upon completion of these treatments, both groups were administered a science teaching attitude measure.

The attitude measure used in this study was an instructor-designed instrument consisting of 30 statements. Each statement concerned teaching science as a process or as a body of knowledge. The subjects responded to each statement on a Likert-type scale with five categories ranging from strongly agree to strongly disagree. The reliability of this attitude measure was determined on three occasions using the test-retest method with subjects not involved in the study. Pearson product-moment reliability coefficients of .76, .81, and .86 were obtained.

The scores obtained from the attitude measure were analyzed by a t-test.

The mean total score from the attitude measure for the control group was 120. The mean total score for the experimental group was 133. The resultant t value was significant at the .05 level.

Based on the results of this study, it would appear that training inservice elementary teachers in the science process skills and subsequently teaching these skills to children in microteaching sessions had a significant and positive effect on teachers' attitudes toward teaching the science process skills.

Although a few studies have shown that training teachers in the science process skills has a positive effect on their attitude toward teaching these skills, the immediate use of these skills in classroom situations produces a greater positive affective effect. If a goal of science education is to train elementary teachers in the process skills with the hope that these skills are taught in the elementary classroom, then process skill training plus process skill microteaching appears to be a positive move in this direction.

THE EFFECTIVENESS OF INSTITUTES FOR CHANGING THE PHILOSOPHY OF TEACHING ELEMENTARY SCHOOL SCIENCE

David R. Stronck
Washington State University
Pullman, Washington 99163

Paul DeHart Hurd and James Joseph Gallagher in their book, New Directions in Elementary Science Teaching, observed that a condition important for "the diffusion of curriculum innovations into schools" is "the acceptance of the idea underlying the innovation, its rationale or philosophical assumptions." Therefore one of the primary goals for an inservice institute introducing an innovative curriculum should be to change the participants' philosophy of teaching. The objective of this study was to analyze the achievement of this goal in several inservice institutes which were designed to prepare teachers for implementing the Elementary Science Study (ESS) and the Science Curriculum Improvement Study (SCIS).

A ten-item questionnaire was prepared with three alternatives for each item. Based on the wording in New Directions in Elementary Science Teaching, one alternative presented the ESS philosophy; another, the SCIS emphasis; the third alternative described a more structured but commonly used approach. Participants in three institutes completed this questionnaire, both at the beginning and at the end of each institute. Using the t-test on paired observations, the following null hypothesis was tested: there is no significant difference in the philosophy of teaching described on the questionnaire between the responses of participants before the institute and their responses after the institute.

Three groups twice completed the questionnaire: (1) 36 teachers in an institute emphasizing ESS but also considering SCIS, (2) 140 teachers in an institute on SCIS but also presenting some units of ESS, and (3) 25 curriculum consultants in an institute giving equal emphasis to ESS and SCIS. The same questionnaire was completed once by 35 elementary school principals and by 45 junior high school principals.

For the SCIS scores, the null hypothesis was not rejected for both groups of teachers and by the curriculum consultants. But it was rejected for all three groups for the ESS scores. Teachers in the first institute significantly changed toward the philosophy of ESS at the 0.01 level of confidence; teachers in the second institute, at the 0.02 level. The curriculum consultants moved away from the philosophy of ESS (significant at the 0.005 level).

Both groups of principals selected the SCIS philosophy for approximately half of the items and the ESS orientation for approximately one quarter of their responses. Both the teachers and the curriculum consultants in their pretests selected ESS alternatives for more than one third of their responses and SCIS alternatives with a similar frequency. In the posttest the teachers selected ESS for more than half of the alternatives. The teachers demonstrated a philosophy differing from that of the principals (significant at the 0.001 level).

Institutes can be effective in increasing the frequency of responses by which teachers select the philosophy of ESS. Because many principals prefer a more structured philosophy, the impact of an institute may be to increase the differences between teachers and their principals. Therefore principals should be included within an institute to increase their acceptance of the innovations.

AN ANALYSIS OF SCIENCE TEACHERS' BELIEFS ABOUT TEACHER CLASSROOM BEHAVIORS

Willis J. Horak
University of Arizona
Tucson, Arizona 85721

The objective of this study was to investigate the overall patterns of belief junior high school and senior high school science teachers had concerning teacher classroom behaviors. It also investigated the relationship between the belief patterns of the science teachers and certain selected background characteristics.

Teaching is a complex activity carried on in many vastly differing environments. Effective teaching behavior has been the subject of much research but numerous conflicting results have been reported. No single teacher possesses all the traits listed in behavioral research studies. The assessment of underlying attitudes and beliefs about appropriate classroom behaviors have led to delineation of some of the relevant aggregates of teacher behavior that have importance for the teaching-learning process. Wehling and Charters (1969) identified eight dimensions of teacher's beliefs that emerged with regularity from several factor analysis studies. Harvey, Prather, White, and Hoffmeister (1968) identified four distinct belief systems among teachers and assessed their effects on educationally desirable behaviors. Sontag (1968) similarly analyzed the influence of beliefs and attitudes on teacher's perceptions of desirable teacher behavior. These descriptions of the dimensions of belief systems provide a basis for hypothesizing some of the patterns of teacher behavior.

Q-methodology and techniques were used to analyze the belief patterns of teachers with respect to statements dealing with the behavior of science teachers. The Q-sort instrument was developed specifically for this study. Statements pertaining to eight broad categories of teacher behavior that have been systematically observed and analyzed were included in the instrument.

The science teachers involved were from a mixture of rural and urban, and junior and senior high schools in a regional area. All teachers in the participating school systems were personally contacted for this study. Data were collected from 67 of the teachers. In addition to sorting the 80 behavioral items into a quasi-normal distribution on an eleven point scale ranging from most-important to least-important in relationship to their beliefs about teaching, they supplied data pertaining to their specific background characteristics.

Three distinct science teacher types were identified through the study. All the behavioral categories in the instrument were important in characterizing and differentiating the three patterns of belief. Overall Type I science teachers favored student-centered indirect teaching behaviors. Type II science teachers favored open classroom communications along with strong discipline and small group activities.

Type III science teachers favored large group activities, structure in their lessons, and flexibility and variety in classroom materials and techniques. Overall background characteristics of the participants were not found to be significantly associated with the three science teacher types.

This study helped define the underlying belief systems of science teachers. The findings were consistent with those of other researchers (Harvey, Prather, White, and Hoffmeister, 1968). This is research needed to uncover the relationships between teachers' belief systems about the educational processes and their classroom behavior. It is also necessary if we pursue the effective pairing of students with teachers for improving productivity of classroom environments.

Harvey, O. J., M. Prather, B. J. White, and J. K. Hoffmeister. "Teachers: Beliefs, Classroom Atmosphere, and Student Behavior." American Educational Research Journal, 5:151-166, 1968.

Sontag, M. "Attitudes Toward Education and Perception of Teacher Behaviors." American Educational Research Journal, 5:385-402, 1968.

Wehling, L. J. and W. W. Charters. "Dimensions of Teacher Beliefs About the Teaching Process." American Educational Research Journal, 6:7-30, 1969.

A RESEARCH BASED RATIONALE FOR TEACHER INTERVENTION IN THE LEARNING PROCESS

Glenn Clark
Memorial University
St. John's, Newfoundland, Canada A1C 5S7

and

John P. Smith
University of Washington
Seattle, Washington 98105

Good teaching has always been characterized by the teacher who is able to ask the right question or provide the right assistance at the appropriate time. We believe this is due to the teacher's recognition of regularities in the behavior of successive groups of children as they interact with concepts and use processes common to the elementary school program.

The problem, which will be outlined in greater detail following, is to begin to provide teachers with the means and rationale for intervening in the learning process in a way most beneficial to the child.

(1) There is a distinct lack of information about children's learning or failure to learn in particular subject matter contexts. In particular, little, if any, information is available about how variables interior to the child will affect a child's learning or of the interaction of these variables with specific science teaching situations. The level of intellectual operations in the Piagetian sense exemplifies a possible relevant variable interior to the child.

(2) A distinct lack of knowledge exists about verbal and material cues which might be used by teachers to assist students in the learning of science concepts. The child's own set of beliefs dealing with the concepts to be taught is also unknown and little studied in instructional settings.

(3) Finally, and central to 1 and 2 above, is the lack of information on concept learning when the concept involves a complex set of referents as opposed to learning concepts with regard to forms, simple tasks, or easily identified examplars and non-examplars of objects or figures.

In order to begin to investigate these problems, we propose, for selected concepts common to several of the more popular elementary science curricula, e.g. Science - A Process Approach, Science Curriculum Improvement Project, and Elementary Science Study:

(1) To identify and describe the set of beliefs or ideas (extant to the child) a child uses as he arranges objects vis-a-vis other objects, describes relationships, manipulates variables, makes predictions, etc.

(2) To identify, describe operationally, and classify the linguistic cues that aid the child in restructuring his view of the world relative to specific concepts.

(3) Describe the extent to which children of different intellectual levels are able to develop a particular concept.

A clinical study was designed as a preliminary investigation into these topics. The study was intended to yield fairly good quantifiable information on objective (3) while at the same time yielding suggestive, qualitative information on objectives (1) and (2).

Twenty students (4 from each of grades 2-6) were randomly drawn from a school system in the Seattle area. Each of these students was taught a total of three elementary science concepts. Four instructors were randomly assigned to the 60 student-concept pairs, 15 per instructor. It was thought that teaching of several concepts to individuals by different instructors would give information on the maximum level of attainment by individuals as well as indicate learning problems and the methods used by teachers to help students overcome those problems.

Audiotapes were recorded during each of the teaching sessions as well as during pre-teaching Piagetian interviews. The transcripts taken from these tapes form the data base for this study. The Piagetian pretest transcriptions were rated as to level. These ratings were used as an operational definition of intellectual level. Transcripts of the teaching sessions were rated for concept attainment of students. The scale used for ratings of concept attainment was partially abstracted from the teaching outcomes and may not, therefore, be generalizable.

Preliminary analysis done at this time indicates the expected close relationship between intellectual level and maximum concept attainment. Preliminary analysis of transcripts indicates that students of all ages studied have similar difficulties and need similar verbal and material cues in order to progress to higher levels of concept attainment. Paths to the concept level attained appear similar for all levels of intellectual development with level of intellectual development acting as a "lid" that determines the upper level of performance for students.

We feel that the potentially most valuable portion of this work lies in identification of the similar problems encountered by students and elucidation of best sets of linguistic and material cues for overcoming these problems. This study should be viewed as a preliminary one that could act as a paradigm for future research with good practical potential rather than as producing material which is directly applicable at this time.

CONCURRENT SESSIONS III

Session IIIC - Contributed Papers: "Learning"

Presiding: Ronald Raven, State University of New York, Buffalo,
New York 14214.

1. "Contrasting Children's Science-Related Cognitive Skills in High and Low Individualized Classrooms." Marvin D. Patterson, Florida State University, Tallahassee, Florida 32301.

2. "The Effects of Kinetic Structure on Knowledge About and Performance of a Psychomotor Skills: Teaching Students to Use the Compound Microscope." Ellen S. Simmons, University of Iowa, Iowa City, Iowa 52242.

3. "The Effect of Specific and Non-Specific Behavioral Objectives on Eighth Grade PSI Student Achievement." William E. Mosley, Junior High East School, Horseheads, New York 14845 and Paul E. Bell, The Pennsylvania State University, University Park, Pennsylvania 16802.

4. "Predicting Learning Environments From Teacher and Student Personality." Gary C. Bates, Columbus University, New York, New York 10027 and Fletcher G. Watson, Harvard University, Cambridge, Massachusetts 02138.

5. "Strategies for Science Instruction With Native Children in Northern Manitoba Schools." Sylvia Leith and Kenneth Slentz, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

CONTRASTING CHILDREN'S SCIENCE-RELATED COGNITIVE SKILLS IN HIGH AND LOW INDIVIDUALIZED CLASSROOMS

Marvin D. Patterson
Florida State University
Tallahassee, Florida 32301

For a number of years, experienced educators have been espousing the need to develop approaches to instruction that would better accommodate individual differences. Individualized instruction has been proclaimed by many, especially in the past ten years, as a desirable instructional model to adopt.

A number of national projects to individualize instruction have been attempted, such as Individually Prescribed Instruction (IPI), Program of Learning in Accordance with Needs (PLAN), and, more recently, Individualized Science Instructional System (ISIS). Although some studies have been completed that report the cognitive results of such programs, little is known about the relationship between the degree of individualization and student achievement.

The completed study contrasted the science-related cognitive skill attainment of children experiencing high and low individualized science programs. A total of 903 fifth grade pupils from seven schools were given a shortened version of the Bristol Study Skills Test and a Student Questionnaire. Concurrently, 17 teachers were given an Instructional Practices Questionnaire (IPQ) that reported the degree of individualized instruction being practiced.

The major research question of interest was: Are there significant differences in levels of science cognitive attainment of children from "high individualized" science classes in contrast to children from "low individualized" science classes?

The dependent variables of interest in this study were the five subtests of the children's science-related cognitive skills as measured by the Bristol. The test has a strong influence from Piaget on its content and produces five subtest scores: *Properties*, *Structures*, *Processes*, *Explanations*, and *Interpretations*.

The estimate of reliability for the IPQ based on the responses of over 270 teachers in a previous study was .79. The estimate of reliability for the Bristol was .90 as derived from the publisher's reliability coefficient.

Since data from the five subtests of the Bristol were analyzed, multivariate analysis of covariance (MANCOVA) served as a method of analysis. The five subtests of the Bristol served as the dependent variables, while parents' highest educational level was the covariant. To determine the effect of degree of individualized instruction on student performance on the dependent variables, teachers were classified into two groups based on their science IPQ scores. The unique effect of each teacher was treated as a nuisance factor. By using a statistical analysis which was hierarchical in design, the effect of teachers was nested within the high-low individualized groups.

By dividing the teachers into thirds based on their IPQ scores, seven teachers were classified as high individualized and six were classified as low individualized. Seven hundred and one students were subsequently used in the analysis. The multivariate test of overall differences between high and low individualized classrooms was significant (*F*-ratio = 5.3, df = 5, 683) beyond the .001 level. The univariate tests indicated that students from high individualized classrooms scored significantly higher on the first four of the five Bristol subtests.

If science-related cognitive skills are to be included as goals of schools, then appropriate modes of instruction that foster such skills need to be included in the schools' science programs. The results of this study suggest that higher levels of cognitive growth seem to be related to the degree of individualization and to the opportunities students have to perform their own investigations.

THE EFFECTS OF KINETIC STRUCTURE ON KNOWLEDGE ABOUT AND PERFORMANCE OF A PSYCHOMOTOR SKILL: TEACHING STUDENTS TO USE THE COMPOUND MICROSCOPE

Ellen S. Simmons
University of Iowa
Iowa City, Iowa 52242

The objective of this research was to examine the effects of verbal communications on student knowledge about and performance of a psychomotor skill, namely, use of the compound microscope. An empirical research problem guided by theory was synthesized involving task analysis from cognitive psychology as well as O. Roger Anderson's theory of kinetic structure and quantitative techniques.

The two independent variables involved in this study were structure and method. Structure theory predicts that a communication having high structure will facilitate greater knowledge acquisition than will a presentation having low structure. Therefore, half of the students received information having high structure. The other half of the students received the same content except that it was adjusted by changing the word distribution and linkage of discourse units (sentences), thus producing low structure. Furthermore, half of the students received a communication containing the parts of the microscope and the definitions of each part integrated within the presentation. The other half of the students received a communication containing the same definitions; however, they were separated and administered before the remainder of the presentation. The purpose of having two methods was to examine the effects of arranging the subject matter in a hierarchial relationship based upon Gagné's concept of task analysis in conjunction with Anderson's theory and techniques. Accordingly, the full-crossed design called for four treatments--

1. Low structure integrated definitions
2. Low structure separated definitions
3. High structure integrated definitions
4. High structure separated definitions

Eighty 9th grade students at a New York City high school were randomly assigned to one of the four groups. The treatment and testing procedures were administered to individual subjects. A two-way fixed effects analysis of variance was performed with 0.01 level of confidence and $F_{cr} = 7.08$.

Since no interaction effects were obtained, the main effects (structure and method) were examined. Significant effects as measured by the Check List (Manipulative Performance) were found for structure ($F = 37.21$) and method ($F = 27.34$). Significant effects as measured by the Check List (Amount of Time Devoted to Task) were found for structure ($F = 20.35$) and method ($F = 14.44$). A significant effect as measured by the Identification, Definition, and Function Test (Requiring Both Parts Be Correct) was found for method ($F = 207.82$). A significant effect as measured by the Identification, Definition, and Function Test (Requiring Any One or Both Parts Be Correct) was found for method ($F = 195.19$). Significant effects as measured by the Test of Multiple Choice Questions were found for structure ($F = 10.33$) and method ($F = 9.06$).

This study demonstrates that high structure produces higher scores than low structure, and separate definitions produces higher scores than integrated definitions. This research supports Gagné's contention of task analysis--that the best way to learn a performance task is by mastery of the subordinate phase which in turn facilitates positive transfer to the subsequent higher phase.

This investigation extends Anderson's theory by applying it to the psychomotor domain. Anderson has designed a bridge linking learning theory which is largely descriptive with teaching theory which is largely prescriptive. The more knowledgable teachers, supervisors, and teacher educators become about the process of teaching from a systematic viewpoint, the more skilled they will become in developing a theory of instruction or at least a model of effective professional performance.

THE EFFECT OF SPECIFIC AND NON-SPECIFIC BEHAVIORAL OBJECTIVES ON EIGHTH GRADE P. S. I. STUDENT ACHIEVEMENT

William E. Mosley
Junior High East School
Horseheads, New York 14845

and

Paul E. Bell
The Pennsylvania State University
University Park, Pennsylvania 16802

In response to the ongoing arguments over the usefulness of behavioral objectives for instruction, this study was an examination of the influence of objective statement specificity on student learning resulting from the independent laboratory-based Physical Science Investigation program.

The study involved three teachers and 138 eighth grade Regents students from six intact classes. Each teacher taught one section using specific behavioral objectives and one section using non-specific objectives. In both treatments, objective statements were presented to the students prior to the instruction of the unit, Chemical Activity. A non-randomized control group pretest-posttest design was used.

Content for the unit, objective statements, and test items were agreed upon by the participating teachers. Similarly, during the unit, the teachers agreed upon how much of which type of help would be provided the students for which proportion of the unit.

Test items included multiple choice, fill-in and problem-solving questions; all items were given equal scoring weight; no partial credit was awarded for any partially-correct item. The odd/even split reliability coefficient was 0.73. The pretest was comprised of randomly selected items from the pool of contributions by the three teachers. The posttest was a randomly assigned reordering of the pretest items.

Pretest scores showed no significant difference between classes. Two-way analysis of variance of the posttest, administered three weeks following the pretest, generated *f* values that were not significant for the teacher and interaction sources of variance. However, the treatment effects were significant ($P < .05$), higher means were obtained by the groups provided the specific behavioral objective statements. A post-hoc questionnaire indicated student perceptions of the use of behavioral objectives as being helpful generally, helpful in achieving higher grades, and helpful in providing guidance through the unit.

PREDICTING LEARNING ENVIRONMENTS FROM TEACHER AND STUDENT PERSONALITY

Gary C. Bates
Columbia University
New York, New York 10027

and

Fletcher G. Watson
Harvard University
Cambridge, Massachusetts 02138

A persistent intuitive belief exists among educators that the interaction of teacher, student and classroom characteristics has a significant effect on classroom climate. To address this question, linear regression techniques were used to predict selected scales of Anderson's Learning Environment Inventory (LEI) from sets of orthogonal variables which are representative characteristics of the teacher, student group, and class structure. The LEI provides more than a dozen measures of classroom climate such as "Intimacy," "Formality," "Goal Direction," "Disorganization," and "Difficulty." Regression analysis of eight elected scales accounted for 21 percent to 63 percent of the variance for the model group of 72 classes. A replication based on 24 classes supported the regression model for the LEI scales Intimacy, Difficulty, Formality, and Disorganization. Data for the study were drawn from the Harvard Project Physics (HPP) Summative Evaluation Data Bank which represents a true national random sample of 54 physics teachers with 3085 students in 103 classes. This sample allows some confidence in generalizing the results to the universe of physics teachers and classes in the United States.

STRATEGIES FOR SCIENCE INSTRUCTION WITH NATIVE CHILDREN IN NORTHERN MANITOBA SCHOOLS

Sylvia Leith

and

Kenneth Slentz
University of Manitoba
Winnipeg, Manitoba R3T 2N2

The major purpose of this study was to identify those teaching strategies which are most effective for science instruction in northern Manitoba schools. These identified strategies have formed the basis for a science methods module for student teachers electing to teach in northern schools.

Teaching methods must take cognizance of the culture and environment in which instruction takes place. Experience with the supervision of student teachers in native schools of northern Manitoba has indicated that generally accepted teaching strategies may not be effective. Kalra, in working with native Indian children in British Columbia, recognizes that problems exist in motivating Indian children in science and suggests a value-clarifying strategy incorporating their cultural heritage and value system. This present study postulates that certain teaching strategies, when used for science instruction with native children, will maximize both achievement and attitude towards science instruction.

Sixteen student teachers were selected to teach for a five-week period in northern Manitoba schools. Prior to this teaching experience each student teacher reviewed and practiced six distinct teaching strategies. The six strategies had previously been identified as those most frequently used by teachers of native children. Each teacher implemented a number of the strategies at various cognitive levels and collected data as to the students' achievement and attitude towards the instructional strategy. The sample consisted of children from 25 classrooms in 8 different northern schools. Grades from 4 to 11 were represented. Each student teacher was supervised by a Faculty of Education staff member. The staff member's observation of the teacher's use of the strategies complemented the study. Some of the questions considered by the study were:

1. What is the relationship between the students' attitudes and the mean perceived success for each of the six teaching strategies?

2. What is the relationship between the perceived success and the cognitive and affective level of the objectives, relative to each teaching strategy?

Two comparable attitude scales were developed for measuring the students' attitude toward the teaching strategies. The grade 4 to 6 instrument utilized sad - to - happy faces on a Likert-type scale, whereas the grade 7 to 11 instrument used parallel items with a Likert-type line ranging from like to dislike. Both attitude scales of the Attitude toward Science Strategy Scale were administered to all the children in the study as a post test. Achievement was determined by teacher constructed tests.

Analysis of the data for grades 4 to 6 indicated that the most frequently used strategy (questioning) was least liked by native children. The student achievement as a result of this strategy was reasonably high. The data for grades 7 to 11 also indicated that questioning is most frequently used; this strategy was also least liked by this group. The student achievement for this strategy was very high. The most successful teaching strategies used with the elementary children were the experimental approach and activity sessions; whereas the most successful strategies for the secondary group were information-centered assignments and questioning. The least successful strategy for both the elementary and secondary children was values discussion.

CONCURRENT SESSIONS III

IIID - Editorial Board Meeting

Presiding: David Butts, Editor, Journal of Research in Science Teaching,
University of Georgia, Athens, Georgia 30602.

CONCURRENT SESSIONS IV

Session IVA - Symposium: "Formal Thinking"

Presiding: Warren Wollman, University of California, Berkeley, California 94720.

"The Meaning of Formal Thinking and Its Relation to Science Teaching"

Warren Wollman
University of California
Berkeley, California 94720

Anton E. Lawson
University of California
Berkeley, California 94720

Marcia C. Linn
University of California
Berkeley, California 94720

John Renner
University of Oklahoma
Norman, Oklahoma 73069

THE MEANING OF FORMAL THINKING AND ITS RELATION TO SCIENCE TEACHING

Warren Wollman
University of California
Berkeley, California 94720

Anton E. Lawson
University of California
Berkeley, California 94720

Marcia C. Linn
University of California
Berkeley, California 94720

John Renner
University of Oklahoma
Norman, Oklahoma 73069

Piaget's theory of formal operations appears quite relevant to the teaching of science and mathematics. Profitable use of Piaget's concepts is limited by current confusion over the meaning and measurement of formal reasoning. Clarification would result not only in more reliable assessment of students' reasoning, but also in designs of materials and instruction procedures more likely to promote the transition from concrete to formal reasoning (far fewer than 50% of adults perform consistently at a formal level on Piagetian tasks).

The possibility is strengthened that teaching methods can be harmonized with the mechanisms of the psychological growth of reasoning abilities. This can be brought about by careful analysis of the intellectual demands placed on students and relating of these demands to standard tasks for assessing spontaneous intellectual development. Teaching methods can be designed to promote and refine those spontaneous intellectual activities which are observed to be instrumental in this development.

Relations Between Piagetian Tasks and Standard Assessment Measures

Warren Wollman

In order to validate Piagetian-designed formal tasks, a number of studies have been conducted comparing results on these tasks to reading ability, standard achievment scales, aptitudes, class grades, attitudes, and responsiveness to training. Also, pencil and paper "biology" problems have been developed to assess the use of formal reasoning. Items involve the use of combinatorial logic, proportional reasoning, control of variables, and hypothetico-deductive thought.

Characteristics of Logical Reasoning Tasks

Anton E. Lawson

Two methods for presenting controlling variables tasks were compared. Both involved the same number of variables. In one condition the procedure for conducting an experiment was emphasized. In another the results of the experiment were emphasized. The outcome was that 12, 14, and 16 year old children responded differently when presented with the procedure than when presented with the results. Possible explanations of this outcome as well as the educational implications of the investigation will be discussed.

Matching School Science With Piaget

Marcia C. Linn

In order to determine students' ability to use formal operational thought processes to solve problems, a number of "incidents" in science are being constructed. An "incident" is a problem and/or a situation about which the student will be given information. The students then respond in writing to these incidents. To validate the incidents as measures of formal thought, each student responding is also interviewed using several Piaget-designed tasks.

Precursors of Formal Reasoning

John Renner

The formal stage concepts of controlling variables and proportions were taught in a manner building upon precursor concepts (analogous or similar to the formal concepts) which are naturally acquired during the developmentally earlier concrete stage. By examining the transformation of these precursor concepts into mature formal concepts, one gains insights into both the psychological mechanisms and the pedagogical practices which insure the effective functioning of these mechanisms. The meanings of some of Piaget's ideas are clarified. Also, some time honored teaching techniques are seen from a new perspective.

CONCURRENT SESSIONS IV

Session IVB - Contributed Papers: "Inservice Teacher Education"

Presiding: Robert Collagan, Morgan State University, Baltimore, Maryland 21239.

1. "Evaluating Teacher and Program Effectiveness Through Pupil Performance Measures." Richard J. Rezba, Anton Lahnston and Diane Lapp, Boston University, Boston, Massachusetts 02215.

2. "Evaluation of a Teacher Designed Middle School Environmental Study Course: An In-Service Teacher Training Project." John J. Koran, Sharon Brower, and Albert W. Strickland, III, University of Florida, Gainesville, Floria 32611.

3. "A Comparative Analysis of Teacher Attitudes in Two National Science Foundation Implementation Programs." Harold H. Jaus and Gerald H. Krockover, Purdue University, West Lafayette, Indiana 47907.

4. "The Association of Use of Nationally Developed Science Curricula and a School's Measured Receptivity to Dissemination." William H. Ward, Jr., University of Minnesota, Minneapolis, Minnesota 55455.

EVALUATING TEACHER AND PROGRAM EFFECTIVENESS THROUGH PUPIL PERFORMANCE MEASURES

Richard J. Rezba
Anton Lahnston
Diane Lapp
Boston University
Boston, Massachusetts 02215

The study reported was developed to

(1) design pupil growth measures for evaluating teacher and program effectiveness,

(2) evaluate the effect of training site on preservice teachers' ability to bring about intended outcomes in pupil learning, and

(3) determine the extent to which preservice teachers could bring about intended outcomes in pupil learning.

The question of whether the curriculum of teacher preparation programs makes any difference in pupil performance is receiving increasing attention. This is due in part to the trend toward competency-based teacher education. Traditionally, the effectiveness of a teacher preparation program has been evaluated on the basis of knowledge preservice teachers have acquired and to some extent on their demonstrated teaching skills. More recently, researchers have advocated the use of pupil performance measures to assess effectiveness. Pupil product criteria are thought to be less inferential and more dictive than teacher-pupil process or teacher presage criteria. While this theoretical position is held by many, the practical use of pupil performance measures has rarely been made.

The purpose of this paper is to report the development, use, and results of pupil performance measures. Measures include one in progress (observing and inferring skills), one planned (mapping skills), and two completed (classification skills; ecological concepts).

The effect of training site on preservice teachers' ability to bring about intended outcomes in pupil learning (classification skills) was evaluated by the pre- and posttesting of 202 pupils. Fifty-nine junior interns were randomly assigned to two experimental groups, group A (in a totally field-based program) and group B (in a university-based program). Preservice teacher effect on pupil learning was further investigated in a second phase of the study. Forty-five juniors in a field-based program were given a specific set of objectives. Their task consisted of designing and implementing instruction on ecological concepts adapted from SCIS Population Unit.

Data on pupil growth in classification skills were used. An analysis of covariance design was generated to test differences between pupils instructed by field-based interns and pupils instructed by university-based interns. Pretest scores were used as a covariate to adjust the dependent variate.

The measurement of the ecological task was accomplished through the pre- and posttesting of 171 K-8 pupils in six field sites. Pre- and posttest means were computed as well as three measures of central tendency of pupil gain scores.

For objective two, a significant difference between pupil groups was found. The pretest mean of pupils instructed by group A ($x = 3.691$) was lower than that of pupils instructed by group B ($x = 4.182$). However, the posttest of pupils in group A was higher ($x = 5.642$) than that of pupils in group B ($x = 5.008$).

For objective three, results revealed strong gains in pupils instructed by the preservice teachers. Several statistics confirm this finding (pre- and posttest means of 6.06 and 10.68; gain scores: mean = 5.16, median = 5.0, and mode = 4.0).

This paper presents the use of pupil performance measures for both teacher and program evaluation. Findings evidence the importance of early and extensive field components to teacher preparation programs and also demonstrate the practicality of pupil growth measures to determine the extent to which preservice teachers can bring about intended outcomes in pupil learning.

EVALUATION OF A TEACHER DESIGNED

MIDDLE SCHOOL ENVIRONMENTAL STUDY COURSE:

AN IN-SERVICE TEACHER TRAINING PROJECT

John J. Koran
Sharon Brower
Albert W. Strickland, III
University of Florida
Gainesville, Florida 32611

A task consistently facing in-service science teachers is the evaluation of either teacher-constructed or commercially produced instructional materials. As accountability becomes a pressing issue on all levels of education with both cost accounting and human productivity purposes, this task becomes even more important since procedures and materials used in science teaching must be supported by effectiveness evidence. For this reason an in-service program has been developed and pilot-tested which emphasizes training in-service science teachers in the skills necessary for both formative and summative evaluation of instructional systems and the development and evaluation of instrumentation for these purposes; Topics covered in this program include: 1) conflicting conceptions of the curriculum; 2) types of learning; 3) instructional design and curriculum planning; 4) summative and formative evaluation/Stake's evaluation mode; 5) experimental and quasi-experimental designs; 6) reliability and validity; 7) exploration and critique of evaluation examples in science. A major objective is to develop critical evaluation skills in science teachers.

An exemplary project was the design and evaluation of a middle school environmental study course[1]. In this project, conducted at a rural middle school, the in-service teacher, directing science education professor and participating graduate assistants in science education designed a sequence of learning experiences suitable for eighth grade students whose reading level was deficient approximately two grade levels. Heavy emphasis was placed in the formative evaluation stages on adapting reading materials and experiences for the students. At the same time instruction emphasized field and laboratory process activities and the development of communication skills.

Prior to this project eighth graders were assigned randomly to three groups. One group was used for the development and formative evaluation phase of this project. The two other groups were used as treatment and control groups in a summative evaluation format. The basic design of the formative evaluation of materials was $R\text{-}X_1\text{-}O_1$. Here a small number of students were randomly selected from a pool of non-participants, exposed to an instructional system and subsequently evaluated for achievement and interviewed for interest, motivational and attitudinal factors. The instructional materials were then modified,

---

[1] A project partially supported by the State of Florida Environmental Education Division of the Department of Education.

The basic design of the summative evaluation format was:

$R_1 \quad X_1 \quad O_1$

$R_2 \quad \quad O_2$

Here X_1 represents the entire semester-long course of study, and O_1, O_2 represents a teacher-designed achievement test administered to the treatment and control groups. Since formative evaluation data were gathered with the intent of materials improvement, none will be reported here although data covered laboratory performance, worksheet construction, reading level evaluation, 14 quizzes and two major examinations.

The reliability of the O_1, O_2 post test examinations was .77. Table I below shows the summative evaluation results with significant differences between the treatment group (students who received the new program, emphasizing environmental concepts) and the control ($p < .05$), as determined by a t-test.

	Environmental Concepts Program	Control
Number of students	95	96
Mean Score - Post Test	*17.81	10.35
Standard Deviations	5.53	4.17

* $p < .05$

This project had two objectives: 1) to expose in-service science teachers to evaluation literature, theory and procedures; 2) to assist in-service science teachers in the design of instructional materials and the execution of a small scale, teacher-initiated, curriculum development and evaluation project. Both of these objectives were achieved with evidence for the first gathered from teacher performance in a university class and the second gathered from in-school application and execution.

As science teachers become more and more bombarded with materials and various aids, it would appear essential that they ask the critical question, "Will this instructional system, if adopted, make a difference in learning?" and also have the knowledge and skills to gather data facilitating an answer. This program provides evidence to suggest that teachers can not only master this task, but master it well.

A COMPARATIVE ANALYSIS OF TEACHER ATTITUDES IN TWO NATIONAL SCIENCE FOUNDATION IMPLEMENTATION PROGRAMS

Harold H. Jaus

and

Gerald H. Krockover
Purdue University
West Lafayette, Indiana 47907

Most public schools have made a commitment to the development and implementation of a K-12 science program. Yet, designing these programs to have a reasonable sequential development has presented many problems. The 50th Yearbook of the National Society for the Study of Education states that one of these problems is a lack of communication and understanding between elementary and secondary school teachers.

Two suggestions for improving the communication between elementary and secondary teachers have been to involve these teachers in K-12 NSF Instructional Improvement Implementation Programs and to involve these teachers in team teaching situations. The purpose of this study was to determine the effects of elementary teachers' attitudes toward several communication variables when placed in a combined elementary-secondary teaching team.

An experimental group of inservice elementary (n = 26) and secondary teachers (n = 20) participating in an NSF implementation program were placed in "mixed" teaching teams, e.g., a third grade teacher teamed with a high school physics teacher. These teams then provided instruction to a group of ten elementary pupils for one week. After each week, for a period of three weeks, new teaching teams were organized. For example, the third grade teacher would now be teamed with a junior high science teacher and the physics teacher teamed with a first grade teacher. A control group of elementary teachers (n = 27) also attending an NSF program were involved in team teaching but the teams consisted of only elementary teachers. Upon completion of the programs both groups of elementary teachers were administered an attitude measure.

The attitude measure used in this study was an instructor-designed Likert-type instrument consisting of 15 statements. This instrument was designed to measure the attitudes of elementary teachers toward 1) working with and understanding secondary teacher's problems, 2) teaching at various grade levels, 3) work load, and 4) team teaching. Reliability for this measure was determined by the test-retest method using 54 elementary and 15 secondary teachers not involved in the study. A Pearson product-moment correlation coefficient of 0.85 was obtained.

The scores obtained from each statement of the attitude measure were analyzed by a one-way analysis of variance.

The analysis of variance results of the elementary teachers' scores showed two attitude measure statements to be significant at the 0.01 level and four statements to be significant to the 0.10 level. The difference in mean scores always favored the experimental group.

It was found that the elementary teachers who had taught with secondary school teachers were significantly opposed to the ideas that 1) elementary teachers deserved to be paid more money, and 2) elementary teachers worked harder than secondary teachers. These same teachers also believed that secondary teachers 1) could teach effectively in the elementary school, 2) had as many discipline problems as elementary teachers, and 3) were enjoyable team teaching partners. Perhaps of greater importance was the fact that the elementary teachers of the experimental group believed healthy communication with secondary teachers was possible and important.

Designing science programs to have a sequential development encompassing grades K-12 is a viable and necessary goal of education. This goal becomes more tenable if effective communication has been developed between elementary and secondary teachers. Elementary and secondary teachers who understand and are cognizant of each others' problems, teaching skills, and feelings are more likely to develop effective K-12 science programs than teachers who do not have this understanding. Mixing elementary and secondary teachers in team teaching situations can be an effective means of encouraging and implementing this understanding and awareness.

THE ASSOCIATION OF USE OF NATIONALLY DEVELOPED SCIENCE CURRICULA AND A SCHOOL'S MEASURED RECEPTIVITY TO DISSEMINATION*

William H. Ward, Jr.
University of Minnesota
Minneapolis, Minnesota 55455

The diffusion process of science curricula (such as those sponsored by the National Science Foundation) from their central development projects into the nation's classrooms is an interest of many science educators. It has been suggested by Ronald Havelock and others that irrespective of the particular dissemination (diffusion, implementation) strategy used or the article to be disseminated, one or more of seven factors appears to be active in controlling the observed phenomena. By crossing these factors with the four elements common in a communication process, a 28-cell array is generated.

The current study is an attempt to assess the strengths of the receiver of an innovation, herein conceptualized as the school and specifically the science department, relative to the seven identified factors.

The specific objectives of the study are:

(1) To develop an instrument yielding quantitative measures of a school climate along the seven dimensions identified by Havelock and others.

(2) To search for indications of relationship between a school's factor strengths and weaknesses, and its use of NSF sponsored science curricula.

Two forms of a self-report instrument have been developed, one specific to elementary schools and one specific to secondary schools with a departmentalized structure. Each yields seven "factor scores" and current use rates for curricula of interest.

Two possible relationships of factor strengths to use are being investigated; a compensatory model and a threshold model.

A pilot test of the elementary school form has been conducted using buildings randomly sampled from the school system of one major city (N = 18). A single observation on each building, a self-report by the principal, was used.

Currently in progress is a major administration (N schools = 200) of the secondary school form to a random sample of secondary schools in a Midwestern state. Multiple independent measures (principal plus three teachers) are being sought in 40 buildings, while in the remaining buildings only the principal's response is being gathered.

---

*This study was supported by Grant GW-6800 from the National Science Foundation.

From the data of the pilot test:

(1) A multiple regression equation was calculated yielding an $R^2 = .74$.

(2) Several factors which logically did not seem orthogonal were rated as having pairwise correlations ($> .6$).

(3) No thresholding was identifiable.

While the squared multiple correlation is doubtless inflated somewhat by the low ratio of cases to independent variables, it may also be depressed to some degree by the homogeneity of the pilot sample. The size of the pilot sample was probably too small to detect any but the most gross thresholding effects that might exist.

The results of the pilot were judged sufficiently encouraging to proceed with the major administration of the secondary school form to a larger and more heterogeneous sample.

This study may be useful in substantiating (or refuting) the association of the adoption and use of nationally developed science curricula to the proposed seven facilitating factors and may aid in describing the nature of the relationship. If these can be established, the instrument would be of value in mapping general diffusion barriers on a state, regional, or national basis.

CONCURRENT SESSIONS IV

Session IVC - Contributed Papers: "Learning"

Presiding: Frederick P. De Luca, Iowa State University, Ames, Iowa 50010.

1. "The Effects of the Science Curriculum Improvement Study on a Child's Self-Concept and Attitude Toward Science." Gerald H. Krockover, Purdue University, West Lafayette, Indiana 47907 and Marshall D. Malcolm, Louisiana State University, Baton Rouge, Louisiana 70803.

2. "Students' Science Attitudes and Self-Concepts in Science as a Function of Role Specific Pupil/Teacher Interpersonal Compatibility." Larry E. Schafer, Syracuse University, Syracuse, New York 13210 and Robert A. Vargo, Colgate University, Hamilton, New York 13346.

3. "The Effects of Objective Based Diagnostic Tests and Help Sessions on the Achievement of Undergraduate Physical Science Students." Martin L. Goodson, Jr., Alabama A & M University, Huntsville, Alabama 35811 and James R. Okey, University of Georgia, Athens, Georgia 30601.

4. "The Effects of Instructional Sequence and Cognitive Style on the Achievement of High School Biology Students." Claudia B. Douglass, Purdue University, West Lafayette, Indiana 47907.

5. "Levels of Learning in High School Science."
Donald W. Humphreys, Temple University, Philadelphia, Pennsylvania 19122.

THE EFFECTS OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY ON A CHILD'S SELF-CONCEPT AND ATTITUDE TOWARD SCIENCE

Gerald H. Krockover
Purdue University
West Lafayette, Indiana 47907

and

Marshall D. Malcolm
Louisiana State University
Baton Rouge, Louisiana 70803

Several studies have shown that a child's self-concept can be enhanced or improved via the educational program selected. The purpose of this investigation was to determine if instruction in an existing elementary school science curriculum program, Science Curriculum Improvement Study (SCIS), can be instrumental in helping a child to either maintain or develop a positive self-concept.

Eight classes of elementary school children (grades three to six), two classes per grade level, totaling 189 students, served as the experimental subjects. One class per grade received the treatment condition (SCIS science program) while the control group used a textbook approach. This study lasted for 18 weeks.

There were three independent factors associated with this quasi-experimental study: (1) grade (four levels), (2) method (two levels) and, (3) sex of child. The outcomes were measured by three dependent measures administered on a pretest-posttest basis: (1) the Piers-Harris Children's Self-Concept Scale, (2) the SCIS "Faces" attitude instrument, and (3) the "Science Report Card" class perception instrument.

A three-way Analysis of Variance (4 x 2 x 2) and the Newman-Keuls range test were used to analyze the data.

Data from the Piers-Harris scale was analyzed by total score and then divided into six factors: Behavior, Intellectual and School Status, Physical Appearance and Attributes, Anxiety, Popularity, and Happiness and Satisfaction. Data were also collected utilizing the SCIS "Faces" attitude instrument and the "Science Report Card" class perception instrument.

An analysis of the findings resulting from significant F ratios and the Newman-Keuls test permits the following conclusions:

1. On the Piers-Harris Scale, the experimental group showed significant differences in high self-concepts over the control group in the areas of intellectual and school status and in physical appearance and attributes.

2. There was a significant difference in favor of the third grade girls control group on the Piers-Harris Scale in the area of happiness and satisfaction.

3. The data from the SCIS "Faces" Instrument indicated significance in favor of the experimental group.

4. The data from the SCIS "Science Report Card" Instrument indicated significance in favor of the experimental group.

This study indicates that the desired outcomes, which science educators believe should occur as a result of participation in an inquiry-orientated elementary science program, do occur. Participation in the SCIS elementary science program does maintain or enhance several areas of a child's self-concept.

STUDENTS' SCIENCE ATTITUDES AND SELF-CONCEPTS IN SCIENCE AS A FUNCTION OF ROLE SPECIFIC PUPIL/TEACHER INTERPERSONAL COMPATIBILITY

Larry E. Schafer
Syracuse University
Syracuse, New York 13210

and

Robert A. Vargo
Colgate University
Hamilton, New York 13346

Science teaching has become more discovery or inquiry oriented. As a result, teachers tend to interact more frequently with individual students. With the increased interaction, pupil/science teacher interpersonal compatibility most likely contributes significantly to the development of students' science attitudes. A study described at the 1974 NARST convention, however, revealed that when measures of general interpersonal tendencies (FIRO-B) were used to determine pupil/teacher interpersonal compatibility, no correlation was found to exist between compatibility and students' science related attitudes. Perhaps no compatibility-attitude correlation was found because the measures of general interpersonal tendencies did not adequately measure teachers' specific interpersonal tendencies toward students nor students' specific interpersonal tendencies toward teachers. A follow-up study (1975 NARST) revealed that when the role-specific interpersonal tendencies of teachers (i.e., FIRO-BT---measures of teachers' interpersonal tendencies toward students) and the general interpersonal tendencies of students (i.e., FIRO-B---measures of students' interpersonal tendencies toward people in general) were used to determine pupil/science teacher compatibility. Compatibility was found to be significantly and positively related to students' science related attitudes.

With only one measure of role-specific interpersonal tendencies (i.e., the teachers), interpersonal compatibility proved to be a better predictor of students' attitudes. Perhaps by using role-specific tendencies of students as well as role-specific interpersonal tendencies of teachers, pupil/teacher compatibility will become even a better predictor of students' science related attitudes. The primary purpose of this study was to develop a measure of the role-specific interpersonal tendencies of students (FIRO-BS), determine pupil/science teacher compatibility from measures of the role-specific interpersonal tendencies of both students (FIRO-BS) and teachers (FIRO-BT), and then investigate the extent to which role-specific pupil/teacher compatibility predicts students' attitude toward science (Science Attitude Scale-SAS) and self-concept in science (Self-Concept in Science Semantic Differential-SCSSD).

In addition, since the role-specific pupil/teacher compatibility, as defined in this study, was determined from measures of interpersonal tendencies rather than from actual interpersonal behaviors, an instrument was developed and used to measure students' perceptions of the actual classroom pupil/teacher interpersonal climate.

Pupil/science teacher compatibility scores, which were derived from formula developed by Schutz (1966), and the students' perceptions of the existing interpersonal climate were used in multiple regression equations to predict students' attitude toward science (SAS) and their self-concept in science (SCSSD).

The subjects used in the study were six different science teachers, all using the discovery-oriented New York State Earth Science Syllabus, and the students in their twelve classrooms. As hypothesized above, with the measures which more accurately index pupil/teacher interpersonal interactions and tendencies in classrooms, greater correlations between interpersonal measures and students' science related attitudes were expected.

THE EFFECTS OF OBJECTIVE BASED DIAGNOSTIC TESTS AND HELP SESSIONS ON THE ACHIEVEMENT OF UNDERGRADUATE PHYSICAL SCIENCE STUDENTS

Martin L. Goodson, Jr.
Alabama A & M University
Huntsville, Alabama 35811

and

James R. Okey
University of Georgia
Athens, Georgia 30601

The intention in this study was to examine alternative ways of using objective-referenced diagnostic tests and remedial instruction in the context of a college help session. The study specifically attempted to assess student learning and retention in physics following various types of help sessions based on objective-referenced diagnostic tests. The study attempted to answer the following questions:

1. Do objective-referenced diagnostic tests followed by remedial help sessions aid students in learning?

2. Is student self-remediation following diagnostic testing as effective as teacher-guided remediation?

3. Are students who use whatever resources are available to them as successful as students in teacher-structured or student-structured help sessions?

4. Do students receiving different kinds of diagnostic and remedial treatments in help sessions perform as well when tested for retention as when tested for initial achievement?

Students from an undergraduate physical science course were assigned to one of four treatment groups and a control group. Each group was a laboratory section selected from a total of 25 associated with the physical science course. Students were treated as if randomly assigned to laboratory sections since they were allowed to select any one of the 25 laboratory sections at the time of course registration. No systematic bias in course selection was noted. The treatments received by the five groups in addition to their participation in a laboratory class were:

1. A list of objectives for each exercise studied, a diagnostic test based on the objectives, and a help session designed for reteaching incorrect responses on the diagnostic test. The teacher noted the problems and structured the help session to remedy them.

2. A list of objectives for each exercise studied, a diagnostic test based on the objectives, and a help session designed to encourage students to ask questions

concerning items missed on the diagnostic test. Students used their test results to structure their own help session with the teacher.

3. A list of objectives for each exercise studied, a diagnostic test based on the objectives, and a help session which advised students to use various resources to find answers to incorrect responses on the diagnostic test. It was the responsibility of students in this group to plan and carry out any remedial work they thought appropriate outside of class.

4. Only a diagnostic test and a help session advising students to use various resources to find answers to incorrect responses on the diagnostic test. This group received the same treatment as group 3 except that they were not given a list of objectives.

5. The control group which did not receive any of the treatments described in the above four groups. Students in this group received only the basic laboratory instruction with no diagnostic tests, feedback or remedial work.

At the conclusion of the three-week study a criterion test of physical science laboratory achievement was administered to all students. A similar test of a comprehensive nature was administered six weeks later as a retention test.

The data used in this study were acquired from 97 undergraduate physical science students. A factorial analysis of variance was used to determine whether or not significant differences in student achievement and retention were due to treatments used in the completely randomized design employed. A priori orthogonal tests were used for making comparisons among means of the five groups, and the Newman-Keuls procedure was used for multiple pairwise comparisons.

Results from this study confirm the value of diagnostic tests. All students taking diagnostic tests performed better than the control group students on both criterion tests.

Among the students that received diagnostic tests a switch in performance on the initial achievement and retention tests was found. On the short term achievement test, students participating in help sessions (either guided by the teacher or themselves) performed better than students who were told to work out their problems as they wished. But, on the retention test given several weeks later, these students that had individual responsibility for remedying problems did significantly better than the students in the help sessions.

Since help sessions are frequently scheduled in science classes at many colleges and universities, their efficient use is important. By investigating the use of diagnostic tests and remedial procedures in different kinds of help sessions, data have been acquired to guide teaching procedures.

THE EFFECTS OF INSTRUCTIONAL SEQUENCE AND COGNITIVE STYLE ON THE ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS

Claudia B. Douglass
Purdue University
West Lafayette, Indiana 47907

The primary purpose of the reported research was to identify a possible interaction between the cognitive style of the students and the instructional sequence of the materials and their combined effect of achievement.

The students were ranked and classified as field dependent or field independent on the basis of their performance on the Group Embedded Figures Test. Then the students were assigned randomly to one of the following three groups: 1) an experimental group pursuing a deductively sequenced package of instruction on classical genetics and probability, 2) an experimental group pursuing an inductively sequenced package of instruction on classical genetics and probability, or 3) a control group pursuing three related units on cell division and chromosomal abnormalities. A measure of general intelligence was obtained for all students, and all students were pretested over the treatment material. The instructional material for all students was of an audio-tutorial, self-paced, mastery format. A comprehensive posttest was the achievement measure. The research was conducted in the biology classes of six midwestern high schools, in which all students were in their first semester of high school biology.

The two levels of cognitive style (field dependence and field independence), the three levels of instructional materials (deductive, inductive, and control), and the six schools were combined factorially in a 2 x 3 x 6 design. Descriptive statistics and correlation coefficients were calculated to provide an overview of the data. Analyses of variance and covariance were performed to investigate all possible main effects and two-way interactions. A step-wise multiple regression was performed to determine the predictive powers of I.Q. and field-dependence-independence on the dependent measure of genetics and probability achievement.

If frustration levels and failure attitudes are to be minimized, students need to be guided carefully to logical and independent thought by curricular materials designed for individualized learning in a manner complementary to their existing thought patterns. This research has helped to identify such materials.

LEVELS OF LEARNING IN HIGH SCHOOL SCIENCE

Donald W. Humphreys
Temple University
Philadelphia, Pennsylvania 19122

Much attention to concept attainment by pupils has been given by authors of many recent curriculum developments and yet how the pupils will develop concept understanding is not clearly stated. In this study an individualized learning module was developed to train science teachers to use the Gagné hierarchy of learning (Gagné, 1965). The module contained approximately four hours of self-instructional exercises which ultimately allowed the teacher to develop concrete instructional materials for each level of the hierarchy.

Eighteen biology teachers from the Philadelphia Public Schools volunteered to be trained using the individualized module. From this population, nine teachers were randomly selected to receive the training, with the remaining nine teachers composing a control group. The teachers in the experimental group were given two one-hour training sessions by the author and completed the remaining work independently. Prior to the completion of the experimental group training, both groups of teachers were given the instructions to teach a unit on organic evolution to their 10th grade biology classes. The control teachers taught the unit as they usually did, while the experimental teachers taught the unit using the Gagné hierarchy of learning. Teachers gave an achievement test at the completion of the two week unit. The test was constructed by the experimenter and contained both factual and concept level questions.

The students of teachers receiving the training demonstrated concept understanding better than did the students of teachers not receiving the training to a statistically significant level. No significant differences existed between the two groups on the factual or recall level questions.

The small sample limits the generalization of the study, but the results add credence to Gagné's hierarchy. The module seemed to train the teacher in concept development satisfactorily. Finally, the results of the study indicate that pupils can achieve greater concept understanding if teachers are first trained to use learning theory adapted to a hierarchial scheme of learning.

Gagné, R. M. The Conditions of Learning. New York: Holt, Rinehart, and Winston, 1965.

Humphreys, D. W. Levels of Learning: A Module for Secondary Teachers. Philadelphia: Temple University, 1975.

CONCURRENT SESSIONS IV

Session IVD - Contributed Papers: "Conceptual Models"

Presiding: William G. Holliday, The University of Calgary, Calgary, Alberta, Canada.

1. "The Effects of Manipulative Versus Pictorial Feedback in Learning a Science Principle." F. David Boulanger, University of Illinois at Chicago Circle, Chicago, Illinois 60680.

2. "Problem-Solving Behaviors as a Function of Instructional Mode, Conceptual System, and Field Independence in a CAI Environment." Michael Szabo, The Pennsylvania State University, University Park, Pennsylvania 16802 and Anthony Lazzaro, California State College, California, Pennsylvania 15419.

3. "The Use of Evidence, A Study of Problem Solving Processes." Mary Budd Rowe, University of Florida, Gainesville, Florida 32611.

4. "Cognitive Preference Styles Across Three Science Disciplines." Pinchas Tamir, The Hebrew University, Jerusalem, Israel.

5. "Advanced Concept Formation at an Early Age in Comparison with Conventional Concepts: Introducing the Atomic Theory Compared to the Concept of Volume." W. W. Wassef, University of Tanta, Tanta, Egypt.

THE EFFECTS OF MANIPULATIVE VERSUS PICTORIAL FEEDBACK IN LEARNING A SCIENCE PRINCIPLE

F. David Boulanger
University of Illinois at Chicago Circle
Chicago, Illinois 60680

The objectives of this study were: (1) to examine the effects of two modes of feedback, manipulative and pictorial, on measures of application, transfer, instructional time and instructional efficiency; and (2) to search for an aptitude-treatment interaction using the Mathematics subscale of the American College Test (M-ACT) as the measure of aptitude.

Normative research related to Piagetian theory has revealed that many college students are intellectually in the concrete operational stage, especially in the area of scientific reasoning. This finding and the experience of certain teaching oriented scientists (Arons) form the bases for recommending that science instruction for non-science majors, especially elementary education majors, begin with manipulative, problem solving activities suitable to the concrete operational stage. It is also claimed that this approach is more adaptable to different ability levels, more motivating, and as efficient as other approaches.

The hypotheses of this study were that compared to pictorial feedback, manipulative feedback in a problem solving inductive approach to teaching a physical science concept would result in: (1) significantly higher scores on immediate post-tests of applications (to problems similar to the instructional problems) and transfer (application of the principle in a novel physical context); (2) a significantly longer time for completion of the instructional sequence; (3) no difference in instructional efficiency (defined as application score divided by treatment time); (4) a significant aptitude-treatment interaction characterized by little difference between high M-ACT groups but with the low M-ACT manipulative group scoring higher than the low M-ACT pictorial groups.

Three intact classes of elementary education majors were each randomly divided into three treatment groups: one Manipulative group ($n = 26$), one Multiple Pictorial group ($n = 28$), and one Single Pictorial group ($n = 27$). Each subject individually worked the identical set of six problems in pictorial format. Each problem asked the subject to balance an unbalanced beam by either adding, subtracting or moving one weight. After making a prediction, each subject received feedback in one of three ways: try it on the balance beam (Manipulative), a series of drawings of the balance (Multiple Pictorial) and a single drawing of the correct solution (Single Pictorial).

A fifteen item post-test (application measure) containing both multiple choice and construction items similar to the instructional problems and a three part transfer problem requiring novel application of the balancing principle were administered. M-ACT scores, available for 47 out of 81 subjects, were ranked high to low by treatment group and divided into low (M-ACT 19), medium (19 M-ACT 26), and high (M-ACT 26) groups. The nine subgroups thus formed had N's ranging from 5 to 7.

One-way analysis of variance revealed hypothesized significant $(p < .05)$ differences on the application measure and on instructional time and no difference in instructional efficiency, but contrary to hypothesis, no difference in transfer. Two-way analysis of variance, performed on the M-ACT sample subgroup revealed significant $(p < .05)$ interaction effects among the treatment groups and the M-ACT groups only on the application measure. As hypothesized, the low M-ACT Manipulative subgroup scored higher (.76 standard deviations) than either of the pictorial subgroups. Contrary to hypothesis, the high M-ACT subgroups spread widely on retention with the Single Pictorial, Manipulative and Multiple Pictorial groups scoring high, medium and low respectively. The high application score of the low M-ACT Manipulative group supports the theory that the manipulative form of feedback is especially beneficial to the low-ability student. The high M-ACT subjects, perhaps operating in or near the formal operational level are apparently most facilitated in an inductive sequence by the most economical yet complete feedback relevant to the principle sought.

In general, this study supports the view that among inductive approaches, manipulative based feedback is as instructionally efficient as pictorial approaches and is particularly beneficial to the low aptitude college student.

PROBLEM-SOLVING BEHAVIORS AS A FUNCTION OF INSTRUCTIONAL MODE, CONCEPTUAL SYSTEM, AND FIELD INDEPENDENCE IN A CAI ENVIRONMENT

Michael Szabo
The Pennsylvania State University
University Park, Pennsylvania 16802

and

Anthony Lazzaro
California State College
California, Pennsylvania 15419

This study is one of a related series designed to investigate problem-solving performance of human subjects while engaged in the solution of complex, data rich, and real problems in a computer environment. In the present study, behaviors and strategies exhibited in solution space were studied as a function of three theoretically relevant variates: one treatment variate, one personological variate, and one cognitive style variate.

Pursuant to the question "(How) Can Problem-solving behaviors be imparted to the learner?", behaviors and strategies employed during solution of a complex problem were studied (Bloom and Broder, 1950; Fattu, 1964). Reflecting on previous investigations of problem-solving prompted Cronbach (1966) to suggest a need for more complex experimentation that contains a five-fold interaction.

The problem used is a highly engaging quest to solve the riddle of the frozen wooly mammoths. A computer-assisted instruction (CAI) environment was used to administer the problem, react on an interactive basis to solution paths taken by Ss, and collect performance data (protocol analysis). Correctness of solution to problems with simple structure was not considered. The program was developed, debugged, and validated during a fourteen month period in a major CAI laboratory.

Two alternative "instructional" programs were developed. The first engages the problem-solver in the data base with minimal instruction; the second reacts to the internal logic and consistency of input from the problem-solver by means of heuristic feedback. In both modes the Ss is requested to formulate hypotheses to explain the observations surrounding the demise of the mammoths and to use the computer as a data base (callable in natural language) to test the hypotheses formed. No listing of contents of prestored data is provided to the Ss, in order to more nearly simulate reality.

Harvey's theory of Conceptual Systems (1961, 1970) suggests that individuals with a more abstract framework of beliefs, as compared to a concrete individual, should be capable of more flexible and successful behaviors in a data rich environment. Witkin's research in Field Independence (1962, 1973) leads to the prediction that the analytic individual will employ a sharper, more critical, and hence more successful set of problem-solving behaviors.

The literature on these variates strongly implies the need to control for performance differences related to sex classification, general ability, and prior experience with CAI.

Subjects were 120 education undergraduates who were classified into two levels of analytic ability (Group Embedded Figures Test) and three levels of abstractness/concreteness (Conceptual Systems Test). They were then randomly assigned to either problem mode (I) or heuristic-discovery mode (II) treatment levels from joint I.Q. and sex strata. The problem-solving behaviors selected as criterion variables included the number of requests for data (DATREQ), number of data matches (DATMCH), time search in problem space (TMSRCH), DATREQ per unit of time, DATMCH per unit time, and number (NUMHYP) and quality (QALHYP) of hypotheses generated. Data were analyzed using a series of multifactor ANOVA designs and the .05 level of significance. Criterion data were collected during the two hour experiment which took place on-line with the interactive CAI system.

Significant differences which favor mode I (problem mode) were found for the criterion variables of DATREQ, DATMCH, TMSRCH, and DATMCH per unit time. No differences were observed between modes I and II, DATREQ per unit time, and NUMHYP. Analysis of QALHYP scores is being reviewed; the results will be available for the paper.

The data did not support rejection of the main effects null hypotheses comparing abstract with concrete Ss and analytic with non-analytic Ss. Two way interaction effects between mode of presentation and Conceptual Systems and mode of presentation and degree of analytic ability were not significant. Possible relationships among variables were explored through correlational analysis to permit assessment of the clarity of results.

The importance of this study stems from the immediate outcomes and the long range implications of the developing data base from investigating complex problem-solving behaviors (a form of protocol analysis: Simon, 1975). Significant differences on a number of group problem-solving behaviors clearly suggest the validity of exploring various instructional approaches to the teaching of problem-solving skills. The lack of effects of Cognitive Style and Conceptual System might constitute a valid observation or it might reflect error involved in the gross classification of individuals.

The success encountered in building a computer environment which is sensitive to a wide range of strategies employed by learners in a non-restrictive natural language setting provides encouragement to explore more fully numerous instructional strategies to train problem-solvers.

Bloom, B. S. and Lois J. Broder. Problem-Solving Processes of College Students: An Exploratory Investigation. University of Chicago Press, Supplementary Educational Monograph #73, July, 1950.

Cronbach, Lee J. "The Logic of Experiments on Discovery." In L. E. Shulman and E. R. Keislar, Learning by Discovery: A Critical Approach. Chicago: Rand McNally and Company, 1966.

Fattu, N. "Experimental Studies of Problem-Solving." Journal of Medical Education, 39(2), February, 1964.

Harvey, O. J. "Beliefs and Behavior: Some Implications for Education." The Science Teacher, Vol. 37, No. 9, December, 1970.

Simon, H. A. "Knowledge and Skill in Problem Solving." A paper presented at the AERA Convention. Washington, D.C., 1975.

Stolurow, Laurence M. "Applications of Psychology to Educational Technology." Educational Technology, Vol. XII, No. 12, December, 1972.

Witkin, H. A. "The Role of Cognitive Style in Academic Performance and in Teacher-Student Relations." (Mimeo) Educational Testing Service, February, 1973.

THE USE OF EVIDENCE, A STUDY OF PROBLEM SOLVING PROCESSES

Mary Budd Rowe
University of Florida
Gainesville, Florida 32611

This paper reports the results of an in-depth observational study of the ways 300 pairs of sixth graders solved a problem. Its focus is on process. While in recent years science educators have talked about process, there have been too few studies of the ways children think and function when confronted with a science problem of some complexity. There are questions that need answers if we are to develop satisfactory diagnostic or intervention procedures. How do students use evidence as it accumulates to make decisions? What is the function of memory? How much variety is there in the processes or strategies employed in problem solving? How do concepts influence strategy? These are a few of the questions that undergird this investigation.

Students were grouped in pairs according to sex and scores on a locus-of-control measure. The pairs could be further categorized according to ethnic composition. The 320 pairs were randomly chosen from a pool of 5,000 students for whom scores on two locus-of-control measures had been obtained.

The tasks or problems came from an adaptation of a rolling cylinder inquiry which originally appeared in the SAPA program. Pairs were randomly assigned to either a structured or unstructured treatment. To create as standardized an environment as possible, each pair of students came to a trailer which had been designed so that students worked in a room fitted with a one-way window and two-way communication system. The investigator and staff observed from another room.

In the structured treatment, student go through a sequence of three problems in which they are to find the fastest hollow cylinder, the fastest solid cylinder and finally the three fastest cylinders of all. In the unstructured treatment students go directly to the third task. Multiple copies of photographs of each cylinder hang on a board in back of the students. Every time the students run a race, they remove the appropriate pictures from the back board and place them on another board according to how the race came out. Thus, they have available, if they choose to use it, a record of what races were run and how the races turned out.

In addition to an applications test taken on completion of the tasks, each pair of students took an aptitude measure that seemed closely related to the task and is essentially non-verbal (Raven's Progressive Matrices).

COGNITIVE PREFERENCE STYLES ACROSS THREE SCIENCE DISCIPLINES

Pinchas Tamir
Hebrew University
Jerusalem, Israel

Since 1964 when Heath introduced cognitive preference tests into curriculum evaluation, several studies have shown that, in the realm of a certain discipline, the nature of the curriculum, the curricular orientation of teachers, the school environment and achievement are all related to cognitive preference styles of students. Two related questions are the focus of the present study:

(a) How do cognitive preferences of the same students in physics, chemistry and biology compare with each other?

(b) To what extent do cognitive preferences cut across these three disciplines? In addition the effects of sex, achievement and the school environment on cognitive preferences and their interrelationships have been studied.

Three 20 item cognitive preference tests in physics, chemistry and biology were administered to 599 10th grade students of city, occupational and agricultural schools. Achievement was represented by the end of year school grades. Means, standard deviations, analysis of variance, t-tests, correlations and factor analysis were employed. The following are the major findings:

1. In all three disciplines Israeli 10th grade students had a strong bias for principles. The general order of preference appeared to be Principles (P) → Recall (R) → Application (A) → Critical Questioning (Q).

2. Significant differences were found among the three disciplines. P-A scores were highest for biology and lowest for chemistry.

3. Factor analysis results showed that, in spite of some interdisciplinary differences, cognitive preferences cut across the three disciplines. Apparently a general science cognitive preference style is present in 10th grade students.

4. There were practically no differences in cognitive preference between boys and girls.

5. Significant differences were found among the three types of schools which were best demonstrated by their Q-R (Curiosity) and P-A (Utility) scores. Thus, 10th grade students in Israel tend, on the average, to occupy a rather low position on the "Curiosity Scale" with occupational schools leading toward R. On the "Utility Scale," however, the whole sample mean score is relatively high (i.e. students tend to prefer "pure"

over "applied" aspects of science). Students in agricultural schools lean strongly toward the A pole, while students in city schools occupy the opposite position.

6. Unlike previous studies, no significant correlations were found between achievement and Q-R scores. However, achievement was positively correlated to P-A scores.

7. Cognitive styles in physics and chemistry were more similar to each other, compared with each of them and biology.

ADVANCED CONCEPT FORMATION AT AN EARLY AGE IN COMPARISON WITH CONVENTIONAL CONCEPTS: INTRODUCING THE ATOMIC THEORY COMPARED TO THE CONCEPT OF VOLUME

W. A. Wassef
University of Tanta
Tanta, Egypt

There has been a growing need to introduce advanced concepts at an early age for the following reasons: They explain, connect, induce and promote a growing number of facts and concepts; they make retention and use easier; they introduce students into actual life directly; and there are peculiar knowledge and values in such concepts that cannot be introduced otherwise.

Problems investigated were:

Is it possible to introduce advanced concepts at an early age (6-12) in a comprehensible manner?

Would children react positively?

What is the size of the difficulty compared with introducing conventional concepts to the same age group?

Is there a difference between "able" children and "normal" children, or in sex, when introducing such advanced concepts?

What is the natural setting for teaching such concepts?

A basic concept that explains, connects, induces and promotes an enormous web of facts, concepts and sub-concepts is the concept of the atom. This concept, being basic in modern science, was chosen to be introduced to children 10 - 11 years old. A sample of 68 students, in two 5th grade classes in an ordinary primary school, in the Mid-Delta area, was chosen. Class 5A included 30 ordinary students (19 males). Class 5B included the able students, judged by the school, according to their marks. It included 38 students (18 males). The main features of the atomic theory were introduced in a small unit of 5 lessons, each lesson between 1-2 hours per week, according to the conditions. Some simple experiments were conducted to pose problems and arouse inquiry rather than to verify or exhibit ideas. The idea of volume, a traditional concept, and its measurement was introduced in about an hour. It was not studied before, though it was to be introduced in that grade (Formal Syllabus includes cubes and rectangles only). Long decimal divisions were introduced also in that lesson (Formal Syllabus includes it). Comparison of both concepts was not planned in the study. The lesson of volumes and divisions was not intended, but it was given when it turned out that students did not study it. Content of the unit included: observations explained by atomicity (by induction), size of the atom (experiment of the drop of oil), movement of atoms, heat effect, the molecule, difference between atoms, equal volumes of gases contain equal number of molecules under the same conditions of of pressure and temperature, space between atoms, symbols, chemical formula, models, atomic weight, molecular weight, bonds, valence, and chemical equations.

Evaluation of achievement (cognitive) was in the form of a post-test of 50 items covering the unit. Completion of words method was used to avoid guessing and to allow for imagination. The method of answering was explained to the students. Answers were scored either 1 or 0. Because the scoring was artifically divided, answers nearly correct were accepted. Since the content was totally unknown to the students prior to studying the unit, a pre-test was not carried out.

While the mean score for Class 5B (32.2) was slightly higher than for Class 5A (28.9), the difference was not statistically significant. The mean score for the girls in both classes, and for the sample as a whole, was slightly higher than that for the boys. However, the difference (.127) was not statistically significant. Of all 68 students, only one girl from Class 5A succeeded in calculating the correct thickness for the film of the drop of oil on water; 43 students divided size by area without completing the division. Only one student, also a girl from Class 5A, succeeded in deriving from the introductory observations the idea of atomicity.

Students at age 10 can comprehend basic concepts in science very well and some advanced concepts, such as atomic theory, do not appear to be exceptions. While students succeed in comprehending an advanced theory, they sometimes encounter difficulty with a conventional concept, such as volume, thought to be elementary. Such basic ideas in science as those included in the study were found interesting to all students, both average and able. Even a very bright child, able to wittingly derive an important conclusion, did not necessarily score a higher total mark.

Almost all concepts of science should be reviewed and experimented with in a simple direct form in a scale, for all age levels starting from early childhood (6-12). Some conventional elementary concepts are far more difficult for children than adults usually imagine. Perhaps an "index of feasibility" could be developed and calculated to scale such concepts.

AWARD LUNCHEON

Presiding: Ronald D. Anderson, The University of Colorado, Boulder, Colorado 80302.

"Heuristic Learning and Science Education"

J. Richard Suchman
Human Resources Research Organization
Presidio of Monterey, California 93940

CONCURRENT SESSION V

Session VA - Research Design Award Papers

Presiding: Joseph D. Novak, Cornell University, Ithaca,
New York 14850.

CONCURRENT SESSIONS V

Session VB - Training Session: "Dynamic Cognitive Systems"

Presiding: Jack A. Easley Jr., University of Illinois, Urbana, Illinois 61801.

Jack A. Easley, Jr.
University of Illinois
Urbana, Illinois 61801

Charles M. Weller
University of Illinois
Urbana, Illinois 61801

Klaus C. Witz
University of Illinois
Urbana, Illinois 61801

Rosalind Driver
Leeds University
Leeds, England

Gary Knamiller
Arizona State University
Tempe, Arizona 85281

ANALYSIS OF DYNAMIC COGNITIVE SYSTEMS IN TEACHING AND LEARNING

Jack A. Easley, Jr.
University of Illinois
Urbana, Illinois 61801

Charles M. Weller
University of Illinois
Urbana, Illinois 61801

Klaus C. Witz
University of Illinois
Urbana, Illinois 61801

Rosalind Driver
Leeds University
Leeds, England

Gary Knamiller
Arizona State University
Tempe, Arizona 85281

The session will include an introduction to give NARST members enough understanding to determine whether or not they want to participate in the training session. Four papers will be presented focused on a single tape of a science lesson. Because the approach is little known, a composite of excerpts from previous papers will be presented to illustrate how the session might proceed. Plans include presenting analyses of a teacher's perspective on the lesson together with that of one of the pupils which have not yet been carried out. A number of such studies are currently in progress and several are available if needed.

The presentation will include the following parts:

1. Introduction -- Modelling Teacher-Pupil Interactions
   Charles M. Weller

2. The Perspective of Combinatorial Models
   Jack A. Easley, Jr.

3. Physical Deep Structure -- How Do Children Think of Physical Phenomena?
   Klaus C. Witz and Jack A. Easley, Jr.

4. Teacher-Pupil Interaction Analyzed
   Excerpt from Ph.D. Dissertation by Rosalind Driver

5. Discussion

CONCURRENT SESSIONS V

Session VC - Training Session: "Research and Evaluation Designs"

Presiding: James R. Okey, The University of Georgia, Athens, Georgia 30602.

1. "Selecting Research and Evaluation Designs for Studies in Science Education." James R. Okey, The University of Georgia, Athens, Georgia 30602.

SELECTING RESEARCH AND EVALUATION DESIGNS FOR STUDIES IN SCIENCE EDUCATION

James R. Okey
The University of Georgia
Athens, Georgia 30602

Reasons for conducting studies (either research or evaluation) in science education are varied--to determine the effects of field-based methods instruction, to determine the effects on pupils of using different teaching styles, to provide accountability data, or to construct evaluation designs to accompany proposals. For these and other reasons, most science educators need to gather research and evaluation data about such efforts as program or project evaluation, instructional research, and science curriculum development.

Selecting an appropriate data gathering plan (or design) for studies in science education depends on answers to a number of questions such as these: What information is needed? Who wants to use the information? How many teachers and pupils are involved? What kind of control can be exercised over administering treatments and data gathering instruments? What design will provide the information needed at minimum cost?

The purpose of this training session is to help science educators ask and answer these questions. A systematic procedure for selecting designs for studies in science education will be presented. Practice will be given on real and simulated problems to show the application of the procedure to a variety of research and evaluation problems.

Science classroom instructors, curriculum developers, science supervisors, and instructional researchers should find the session helpful in selecting research and evaluation designs. In addition, those who have responsibility for providing data to funding agencies on such things as innovative teacher training programs or curriculum implementation efforts will find the session helpful.

To avoid problems of widely different entering abilities, the training session will be described in a one or two page abstract available before the session so that persons with either too much or too little sophistication will be directed elsewhere.

At the end of the session participants should be able to:

a. Identify and classify questions about which research and evaluation data may be obtained (e.g., questions related to outcomes, antecedents, or transactions).

b. Identify common designs used for research or evaluation studies.

c. Identify strengths and weaknesses of designs in relation to the nature of a study and the context in which it is being done.

d. Select and defend designs to use in science education studies.

The training session is planned to last three hours and will include lecture presentations, individual practice exercises with feedback, question and answer sessions, small group work, and individual post-testing. An approximate time schedule with instructional and participant activities is given below.

Time	Instructor Activities	Participant Activities
0:00 to 0:05	Introduce instructors, distribute materials, review objectives and provide an overview of the session	
0:05 to 0:20	Review of the types of questions about which data may be gathered with examples of each	Classification exercise on types of research and evaluation questions
0:20 to 0:40	Review common research designs from Campbell and Stanley. Exercise on names and nomenclature	Practice exercise on naming and identifying research designs
0:40 to 1:00	Review common evaluation designs. Exercise on names and nomenclature	Practice exercise on naming and identifying evaluation designs
1:00 to 1:20	Present procedure for selecting research and evaluation designs	
1:20 to 1:45	Present sample problems and guide discussion	Group practice exercise and discussion of examples
1:45 to 2:30	Break into small groups to apply design selection procedures to real or simulated problems	Complete simulated or real problems and critique efforts of other participants
2:30 to 2:40	Guide group discussion of design selection using the procedure presented in the workshop	Participate in the discussion

Time	Instructor Activities	Participant Activities
2:40 to 3:00	Evaluation of session with two instruments	Complete evaluation instruments

A packet of materials will be distributed at the beginning of the session that will include a listing of the objectives, an outline for the training session, reprints of several articles, and copies of the practice exercises to be used throughout the session.

Plans for a three hour time block are given here. In the event that the program is planned for training sessions of two hours, cuts in the amount of practice on selecting designs will be made.

Use of a pretest for the session would be valuable in determining a baseline of the participants' skills but the short time available for the training session means that this time should probably be spent on instruction.

Two methods will be used to evaluate the training session and provide feedback to participants, to the instructors, and to the NARST Program Committee. An opinionnaire will be developed to assess the participants' reaction to the content and the methods of the training session. Information from this instrument will be of value to the NARST Program Committee and the instructors in judging the value of the session. A posttest on the final objectives will be developed to assess the success of the workshop in accomplishing the stated outcomes. Results from these will be returned to participants (either at the convention or through the mail) so that they can judge what they have learned. Both instruments can be completed in about 20 minutes.

Several references will be used by the instructors in planning and conducting the training session. Copies of these will be available at the session and a reference list will be given to all participants. The primary references will be:

1. Campbell, D. and Stanley, J. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally, 1963. (This is the classic reference on research and evaluation designs. The Campbell and Stanley designs and nomenclature will be used for the training session.)
2. Gottman, J. and Clasen, R. Evaluation in Education: A Practitioner's Guide. Itasca, Illinois: F. E. Peacock, 1972. (A good handbook with a practical orientation. Especially strong on needs assessment and operational definition.)
3. McNeil, J. and Popham, W. "The Assessment of Teacher Competence." In R. Travers (Ed.), Second Handbook of Research on Teaching. Chicago: Rand McNally, 1973. (A succinct review of procedures for measuring teacher behavior through pupil accomplishment.)

4. Stake, R. "The Countenance of Educational Evaluation." Teachers College Record, 1967, 68, 523-540. (Destined to become a classic paper on evaluation. Stake presents one of the most comprehensive models of evaluation available today.)

5. Welch, W. "The Process of Evaluation." Journal of Research in Science Teaching, 1974, 11, 175-184. (Alternative methods of conducting evaluations in school settings are described.)

6. Worthen, B. and Sanders, J. Educational Evaluation: Theory and Practice. Worthington, Ohio: Charles A. Jones, 1973. (An excellent textbook that provides a comprehensive study of the process of evaluation and a thorough examination of many of the current evaluation models.)

7. For the training session a number of journal articles (primarily from the Journal of Research in Science Teaching and Science Education) will be selected to illustrate the use of designs suitable for science education studies.

CONCURRENT SESSIONS V

Session VD - Paper Set: "Competency-Based Teacher Education"

Presiding: Roger G. Olstad, University of Washington, Seattle, Washington 98195.

1. "Changes in Student Characteristics in a Competency-Based Teacher Education Program." John Hockett, Governors State University, Park Forest South, Illinois 60466.
2. "Value Preferences Among Science and Non-Science Students." Leon J. Zalewski, Governors State University, Park Forest South, Illinois 60466.
3. "Student Characteristics as Predictors of Achievement." Lynne Carter, Governors State University, Park Forest South, Illinois 60466.
4. "Evaluating Cognitive Gains in a Competency-Based Teacher Education Program." Otis Lawrence, Governors State University, Park Forest South, Illinois 60466.

EVALUATING A COMPETENCY-BASED TEACHER EDUCATION PROGRAM

John Hockett
Governors State University
Park Forest South, Illinois 60466

Leon J. Zalewski
Governors State University
Park Forest South, Illinois 60466

Lynne Carter
Governors State University
Park Forest South, Illinois 60466

Otis Lawrence
Governors State University
Park Forest South, Illinois 60466

Governors State University is an upper division (juniors, seniors, and Master's program) institution of learning in which all degree programs are competency-based. Formative evaluation of these programs has been a test of logic and instructional design. Evaluation of student achievement involves the use of data dealing with cognitive and affective changes. Included are four summaries of papers which comprise this paper set.

Changes in Student Characteristics in a Competency-Based Teacher Education Program

John Hockett

Student sharacteristics such as dogmatism, attitude toward science, understanding of science, and personal philosophy of science teaching are thought to influence performance in a CBTE science teaching program. Elements of the GSU program are designed to produce change in these characteristics which will make students more effective science teachers. Data from the TOUS test, Rokeach's dogmatism scale, Schwirian's Science Support Scale, and a local measure (Q sort) of goals for science teaching have been used to (1) measure change over time spent in the program and (2) to compare the effects of different elements in the program in producing change. The results are interpreted to guide sequence development and to aid in both student guidance and instructional revision.

Value Preferences Among Science and Non-Science Students

Leon J. Zalewski

Attitudes and values are very important objectives in any environmental education program. One competency in the Science Teacher Education Program is: Describe and act on a value set based on contemporary science and humanistic thought.

In an attempt to assess value preferences of teachers the Environmental Chemistry Value Preference instrument by Fazio and Dunlop (1974) was given to students. The objective of this instrument is to assess the value preferences of college non-science majors with respect to certain aspects of environmental chemistry. Fazio and Dunlop feel that the value assessments obtained may be useful for science education in formulating objectives which reflect the values of students. Three value scores can be obtained from the instrument: Humanistic, Theory, and Technology value preferences.

The sample of students surveyed for this study were participants taking environmental education and environmental science courses. Results indicate that science teachers had significantly higher Humanistic value preference scores than non-science teachers. Other data are being analyzed to determine if value preferences change for science and non-science teachers.

Student Characteristics as Predictors of Achievement in a Competency-Based Teacher Education Project

Lynne Carter

A self-pacing option at GSU enables students to receive credit for work completed within 16 weeks of the end of a course. The completion date serves as one estimate of the number of trials a student needed to reach competency. Since all students are required to meet the same criteria in demonstrating a given competency, completion date is the only readily available indicator of differences in student achievement. A study has been undertaken to explore the relationship between completion date and such characteristics as:

(1) prior knowledge of the nature of science (Test on Understanding Science, Cooley and Klopfer)

(2) values toward science (Science Support Scale, Schwirian)

(3) references re. mode of college instruction (Questionnaire, constructed by the author).

Measuring Student Achievement of Competencies in a Competency-Based Science Teacher Training Program

Otis Lawrence

Two problems common to competency-based instructional programs are:

(1) How do we know the program competencies are valid?

(2) How do you know when a student has achieved competency?

At Governors State University, it is judged reasonable at this stage of development that the first stated problem - validity of competencies - is resolved by professional academicians identifying the necessary hierarchy of Science Teaching Competencies for both specific and general career contexts after consultation with expert practitioners, and professional groups outside the University.

This report contains a description of a criterion-referenced measurement processing system designed and used at Governors State University to answer the second question. Included in the report are procedures used to organize and code competency statements, to generate test items, to establish item and test banks, to score and analyze tests, and to produce reports.

CONCURRENT SESSIONS VI

Session VIA - Paper Set: "Instructional Research in Science Education: Theory and Application"

Presiding: James H. Townes, Elizabeth City State University, Elizabeth City, North Carolina 27909.

1. "Instructional Research in Science Education: An Organizing Framework," Edward L. Smith, Michigan State University, East Lansing, Michigan 48824.

2. "Learning and Transfer Effects of Strategy-Based Instruction Within a Sequence of Geologic Tasks." Fred N. Finley, Michigan State University, East Lansing, Michigan 48824.

3. "Determination of Relations Between Visual Variables By Sixth Grade Children." Judy K. Dennison, Michigan State University, East Lansing, Michigan 48824.

4. "Retention and Strategy Use Analysis of Nonvisual Seriation Behavior of 1st Grade Children." Michael J. Padilla, University of Victoria, Victoria, British Columbia, Canada V8W 2Y2.

5. "A Task-Content Analysis of an Entomology Lab Curriculum." Richard K. Brandenburg, Michigan State University, East Lansing, Michigan 48824.

INSTRUCTIONAL RESEARCH IN SCIENCE EDUCATION:

AN ORGANIZING FRAMEWORK

Edward L. Smith
Michigan State University
East Lansing, Michigan 48824

The view of the nature of science expressed by Kuhn and Schwab places great importance on the role of "paradigm" or "substantive structures" in the advancement of knowledge. The field of science education has been criticized for its lack of systematic research programs. This paper describes a framework which has served a paradigmatic role in a series of related analyses and empirical studies as well as in curriculum development.

The framework provides for expression of objectives in terms of conceptual networks, tasks associated with the networks, and strategies by which the tasks can be carried out. Such a framework should play both organizing and generative roles. The goals for the present framework are to:

1. suggest possible objectives not otherwise recognized.
2. express relations among objectives which may be instructionally useful.
3. facilitate description and comparison of the objectives of different science programs.
4. point curriculum design toward systematic analysis of the knowledge and methods of source disciplines.
5. clarify the nature of science processes and their relation to content.
6. facilitate the identification and classification of different kinds of concepts.
7. generate or express instructionally relevant research questions.
8. provide consistent descriptions of the instructional context of empirical studies.
9. allow specific expression of fundamental issues of learning and transfer.

Methods have been developed for three kinds of research. Analysis of Potential Objectives -- Content Analysis involves 1) the identification of the types of conceptual systems characteristic of a discipline or subdiscipline, 2) the formulation of a paradigm or analytic network which represents the structure of each type of system, and 3) the comprehensive identification and cataloging of the conceptual systems of a discipline according to the analytic network they exemplify.

Task analysis involves the identification of performance requirements relevant to a specific type of conceptual system. These requirements or tasks are described in terms of the corresponding analytic network.

Skills analysis identifies alternative information processing strategies by which tasks can be performed. These are descriptions of behavior at the psychological level and provide the basis for planning and predicting transfer among tasks.

Studies of Baseline Performance -- These studies use experimental manipulation of task parameters and process tracing techniques to establish performance levels and infer strategies used in performing tasks with specified conceptual networks.

Experimental Studies of Learning and Transfer -- These studies manipulate the strategy taught, task selection and sequencing, and conceptual network selection and sequencing. They examine accuracy of performance, efficiency of learning, and transfer of learning across tasks and conceptual networks.

The results of the work to date suggest the following conclusions:

1. Analyses frequently lead to identification of new objectives and to useful reexaminations of the source areas (6 cases).
2. Learners frequently employ rather systematic idiosyncratic strategies in task performance (3 cases).
3. Strategies for task performance can usually be taught within a given conceptual context (2 cases).
4. Conceptual, task and strategy features allow prediction of transfer relations (2 cases).
5. Instruction on specific strategies may or may not facilitate learning and transfer (2 cases).

The utility of the framework has been demonstrated with several different kinds of research. It may provide a vehicle for coordinating a range of science education research activities currently conducted in isolation.

LEARNING AND TRANSFER EFFECTS OF STRATEGY-BASED INSTRUCTION WITHIN A SEQUENCE OF GEOLOGIC TASKS

Fred N. Finley
Michigan State University
East Lansing, Michigan 48824

The present work addresses fundamental questions of transfer of learning while seeking answers to specific instructional questions in the area of geological classification. Schwab's characterization of disciplinary knowledge as including interrelated substantive and syntactic aspects has been applied in representing the domain of competence in terms of conceptual networks, tasks relevant to those networks, and strategies by which those tasks can be carried out. This analysis allowed the construction of instructional sequences based on shared conceptual, task and strategy aspects. The investigation went on to examine the learning and transfer effects of strategy-based instruction within instructional sequences derived from the analysis.

Two of three studies in the investigation have been completed. The first was to evaluate the learning and transfer of a seriation strategy in a task sequence, and to test protocols and materials. The second study, necessitated by the results of the first, was to develop instructional protocols for a comparison to standard strategy and baseline data on student responses with the geologic materials. The final study will evaluate the learning and transfer value of the new comparison strategy.

Each experimental subject was instructed on strategies for performing a sequence of three strategy related tasks. The final task (T_3) was the classification of igneous rock samples. The second task (T_2) was the classification of the same rocks using each variable separately. The first task was either the serial ordering of the samples (Study I) or the comparison of the samples to standard (Study II).

The performance of the experimental group was compared to that of a comparison group receiving only feedback on the accuracy of their responses.

The students were from fourth grade classes in a small rural school district in central Michigan. There were twenty-eight students in each of the two studies respectively.

The dependent measures used were: (1) the accuracy of student performance, (2) trials to criterion, and (3) strategy criterion.

In the first investigation 80% of the subjects learned the strategy for the single variable classification task during instruction. All students (n = 10) learned the strategy for Task 3. During the posttest, 80% of Ss used the strategy for Task 2 and 77.7% used the strategy for Task 3. Although 60% of the Ss attempted to utilize the strategy for Task 2 in completing the Task 3 pre-test, none were successful.

This result, showing no automatic use of strategy on Task 3, necessitated major changes in the strategy to be used for each task.

The baseline data of the second study (n = 4, n = 8) indicates the comparison to standard strategy for Task 2 was automatically used in the subjects' pre-test attempt at Task 3. The trials to criterion measure indicated fewer trials in learning Task 3 than required by the strategy subjects.

The third study investigating the transfer effects will be included in the report.

The students of both studies learned to use task specific strategies in completing specified tasks. If cognitive strategies serve as a potential mechanism of learning and transfer, and, as in this instance, instruction can be designed to reflect these structures of a discipline, the facilitation of student learning is a potential outcome.

DETERMINATION OF RELATIONS
BETWEEN VISUAL VARIABLES BY SIXTH GRADE CHILDREN

Judy K. Dennison
Michigan State University
East Lansing, Michigan 48824

Some of the most pervasive kinds of science concepts are those which represent variables on which things differ. Developing skill in using such concepts is therefore an important goal of science education. We conceive of such skill in terms of three interrelated aspects: concepts, tasks and strategies. The major assumption underlying this work is that within a discipline concepts of a particular kind (e.g., variables) are associated with particular tasks for which generalizable strategies are developed. A major goal of the work is to examine the roles of these three aspects in learning and transfer.

The objective of the present study was to obtain baseline data about performance accuracy and strategy use by sixth grade children for a task requiring the determination of the relation between two named variables for a given set of objects.

Nine test items were individually administered to each child. Each item presented the child with five irregularly sharped transparent "particles" and the question, "Is there a rule for (e.g., size) and (e.g., darkness)?" The actual relation might be direct (e.g., the bigger, the darker), inverse (e.g., the bigger the lighter) or independent (no rule).

To examine the hypothesis that the child would tend to focus on only the extreme cases, the extreme particles given half the children were designed to distract them to irrelevant variables and give the appearance of a direct rule when none held.

Thirty-six sixth grade children were selected from a rural-village school district in central Michigan using a stratified random sampling. For each item, the experimenter recorded the rule (or other response) and noted whether or not the child ordered or superimposed the particles in performing the task.

The mean score for the nine item test was 6.2 (S.D. = 2.1) or 69 percent of the items correct. 50 percent of the children ordered for at least one item. The number of times a child ordered was correlated with the total test score. (Pearson R = .34: significant, $p < .03$). Comparing scores of the groups getting distracting and non-distracting extreme particles did not provide evidence of focusing on only extreme cases.

These results indicate that:

1. Although there is room for growth, substantial ability exists among sixth grade children to both recognize and verbalize relations of the form "the greater the x, the greater the y."

2. Spontaneous use of an ordering strategy in performing this task is not uncommon among sixth grade children and is associated with more accurate performance.

The significance of this study is shown by:

1. The fact that many sixth grade children are not yet in the formal operational stage does not mean that they have no capacity for dealing with relations between variables. Further exploration of the limits of this capacity is needed.

2. Instruction at the sixth grade level dealing with relations between variables may find the rule form, "the greater the x, the greater the y," useful.

3. Teaching an ordering strategy for determining relations between variables at the sixth grade level may be feasible and should be explored as a means to improve performance on this task.

RETENTION AND STRATEGY USE ANALYSIS
OF NONVISUAL SERIATION BEHAVIOR OF 1ST GRADE CHILDREN

Michael J. Padilla
University of Victoria
Victoria, British Columbia
Canada V8W 2Y2

Several researchers have studied young children's seriation behavior, notably Piaget (3). Most have investigated seriation abilities with visually apparent seriation materials, although Baylor and Gascon (1) have researched weight seriation and this author has investigated weight, force and texture seriation. Smith (4) and Bruner (2) among others have discussed the importance of the strategy in performing certain logical tasks. The purpose of this paper is to report the results of a retention test given to the children involved in the weight, texture and force experiment mentioned above and to analyze those results relative to the immediate post test results. In addition, the seriation strategies used by children throughout the original experiment and the retention test will be analyzed and discussed.

One hundred and twenty first grade students were pretested and divided into a group of stage I seriators (nonperformers) and a group of stage III seriators (operational performers) using Piaget's stick task as the criterion. Twelve children from each group were randomly chosen and assigned to each of three treatment groups. The children in the first treatment, called the EVS, were taught to order the nonvisual materials by choosing the extreme valued object and placing it at the end of a row. This action was repeated until an ordered row was produced. The children in the second treatment group, called the INS, were taught to order the objects by placing each randomly chosen object relative to the other objects in the row until all the objects were ordered. The children in the third treatment group, called the CON, were not taught any specific seriation strategy but rather were allowed to form their own methods of ordering the objects.

The children were trained to criterion in three separate sessions and each session was preceded by a pretest. After training, the subjects were asked to order each set of materials as an immediate post test. Approximately four months later the post test was readministered as a retention post test. Separate scores were calculated which reflected task accuracy and strategy use.

An analysis of covariance was performed on the mean post test task accuracy scores, covarying on the pretest 1 task accuracy scores While no significant differences were evident for any one treatment across stage or for either stage, it was found that one treatment, the EVS, produced more accurate seriators among stage I children ($p \leq .015$). An analysis of covariance on the mean retention task accuracy scores using the same covariate as above indicated a diminished difference among the treatment groups in stage I. No difference was evident among stage III groups as before, although a main effect for stage ($P < .065$) did occur. Thus the post test result showing the EVS

I children scoring significantly higher proved to be short lived although all groups showed a large gain from the pretest scores. A slight task accuracy advantage favoring the INS children, although not statistically significant, lends credence to the conclusion that mastering the insertion capability is one major critical step toward mastery of the underlying logic of an ordered row.

An analysis of strategy use on the immediate post test indicates that fully 89 percent of the EVS III and INS III, 92 percent of the EVS I and 81 percent of the INS I children's tasks were performed using the taught strategies. The retention test strategy analysis shows a lowered percent of taught strategy use for all treatment/stage groups (EVS III = 81 percent, INS III = 69 percent, EVS I = 58 percent, INS I = 39 percent). The higher percentage of strategy retention shown by the EVS III and to a lesser degree by the INS III children indicates a high degree of strategy stability with these children. The lesser retention shown by the stage I children indicates that the learned strategy was only briefly retained, possibly because of the original lack of the logical structures necessary for understanding the seriation task.

Analysis of the CON group's strategies on the immediate post test showed that the stage III CON children used the EVS strategy more than twice as frequently as the INS strategy (55 percent EVS vs. 22 percent INS). The CON I children overwhelmingly preferred the EVS (69 percent vs. 0 INS). Similarly on the retention test the stage III CON used 58 percent EVS vs. 31 percent INS and the stage I CON children used 50 percent EVS vs. 6 percent INS. These results highlight the difficulty of the INS strategy relative to the EVS when strategies are self-developed, especially by stage I children.

---

1. Baylor, G. W. and J. Gascon. "An Information Processing Theory of Aspects of the Development of Weight Seriation in Children." Cognitive Psychology, 6 (1974).

2. Bruner, Jerome. The Process of Education. New York: Vintage Books, 1963.

3. Piaget, Jean. The Child's Conception of Number. New York: W. W. Norton and Company, 1965.

4. Smith, Edward L., et. al. "A Skills Analysis of Selected Primary Level Science Tasks." Technical Note No. TN-2-72-60, Los Alamitos, California: Southwest Regional Laboratory, December 22, 1972.

A TASK-CONTENT ANALYSIS OF AN ENTOMOLOGY LAB CURRICULUM

Richard K. Brandenburg
Michigan State University
East Lansing, Michigan 48824

This paper deals with the curriculum design for a college-level, introductory Entomology systematic laboratory. The terminal objective of this course is to have students identify insects to order by sight inspection, and to family by use of a standard dichotomous taxonomic key. The "classical" course which has students examine insects until they are "familiar with the key" often fails or is inefficient due to the students' inability to correctly identify insect variables and (consequently) develop strategies to complete the terminal task. The objective of this analysis is to identify the knowledge components underlying the course. The results of the analysis can then be used by curriculum developers in course design and improvement.

The complex terminal task is broken down to a number of simpler tasks and the content subdivided into a Variable-Value Network and a Class-Member Network using Smith's Task-Content analytical techniques. A possible arrangement of the tasks from simple to complex promoting vertical transfer is presented, as is an arrageement of content promoting horizontal transfer. A series of progressively more complex strategies, building to a strategy for the terminal task, accompanies the task sequence.

The course content is examined in terms of the terminal objective and a list of 25 useful insect variables generated. A Task-Content Matrix based on these variables is then presented. Five variables are identified as the most useful for identifying the insect as a member of a group of several orders (order set). A strategy (flow chart) is designed using these five variables for such an identification, and a characteristics chart is developed to aid in identifying the specific order, following use of the flow chart. A series of tasks appropriate to a class member network was then designed to aid the student in moving from the variable-value tasks to the terminal classification task. The variable value and class member networks are "blended" at their "intersection" to form a continuous network of tasks and content from which a final curriculum can be synthesized.

The result of this analysis is a complete breakdown of the content, tasks, and strategies for the mastery of the complex terminal classification objective. These parts are all laid out and ready to be assembled into a curriculum by a competent developer, who may choose to omit some components and emphasize others in any number of possible combinations. However, regardless of the final curriculum format, any ambiguity as to the underlying structure has been minimized by this analysis. The analysis provides a range of alternatives for use in revision or research.

This exercise also serves as a general example of the usefulness of task-content analytical techniques in breaking curricula down to their basic components.

Session VIB - Training Session: "Dynamic Cognitive Systems" - Part II

Presiding: Jack A. Easley, Jr., University of Illinois, Urbana, Illinois 61801.

Jack A. Easley, Jr.
University of Illinois
Urbana, Illinois 61801

Charles M. Weller
University of Illinois
Urbana, Illinois 61801

Klaus C. Witz
University of Illinois
Urbana, Illinois 61801

Rosalind Driver
Leeds University
Leeds, England

Gary Knamiller
Arizona State University
Tempe, Arizona 85281

CONCURRENT SESSIONS VI

Session VIC - Training Session: "Research and Evaluation Designs" - Part II

Presiding: James R. Okey, The University of Georgia, Athens, Georgia 30602.

1. "Selecting Research and Evaluation Designs for Studies in Science Education." James R. Okey, The University of Georgia, Athens, Georgia 30602.

CONCURRENT SESSIONS VI

Session VID - Contributed Papers: "Curriculum"

Presiding: Willard J. Jacobson, Columbia University, New York, New York 10027.

1. "An Analysis of Selected Biology Textbooks for the Treatment of Controversial Issues." Florence Levin, Ashland College, Ashland, Ohio 44805 and Joy S. Lindbeck, University of Akron, Akron, Ohio 44304.
2. "Should High School Biology be Taught Before or After Chemistry and Physics?" Donato Leopardi, Syracuse City School District, Syracuse, New York 13202.
3. "A Taxonomy of Science Concepts." Alan M. Voelker, Northern Illinois University, DeKalb, Illinois 60115.
4. "A Chronological History of Selected Objectives for the Teaching of Secondary School Biology in the United States During the 1918-1972 Period, as Reflected in Periodical Literature." William R. Ogden, East Texas State University, Commerce, Texas 75428 and Janis L. Jackson, McLennan Community College, Waco, Texas 76701.
5. "A Survey of the Procedures Utilized by Secondary Schools in the Selection of Science Texts and Programs for Major Classroom Use." William H. Ward, Jr., University of Minnesota, Minneapolis, Minnesota 55455.

AN ANALYSIS OF SELECTED BIOLOGY TEXTBOOKS FOR THE TREATMENT OF CONTROVERSIAL ISSUES

Florence Levin
Ashland College
Ashland, Ohio 44805

and

Joy S. Lindbeck
University of Akron
Akron, Ohio 44304

Since textbooks play a very important part in determining what will be taught in high school classes, the content of biology textbooks is probably the single most important factor in determining what subject matter is included in the biology curriculum. The purpose of this study was to determine the content regarding controversial issues and bio-social problem topics in selected biology textbooks.

Five biology textbooks were selected to represent different types of authorship, different emphasis in material presented, and different positions in biophilosophy. These included the 1973 edition of the BSCS Blue Version, Biological Science Molecules to Man; the 1973 edition of the BSCS Green Version, Biological Science, An Ecological Approach; the 1973 edition of the BSCS Yellow Version, An Inquiry into Life; 1973 edition of Modern Biology by James H. Otto and Albert Towle; and the 1970 edition of Biology, A Search for Order in Complexity.

In this content analysis research, 11 categories of specific content regarding controversial issues and biosocial problems recommended by scientists and science educators for scientific literacy were identified. The categories included Darwinian Evolution, Disease States, Drugs, Environment, Human Genetics, Human Reproduction, Man - His Place in Nature, Origin of Life, Population Explosion, Radiation - Biological Effects of, and Race - Variations.

Each category for analysis was subdivided into subtopics of key words associated with the category; for example, key words for drugs included drugs, addiction and dangers in use of . . .; hallucinogens and psychedelics; alcohol and alcoholism; tobacco; tranquilizers; barbiturates; amphetamines; cannabis; opiates; and methadone. A total of 190 key words for the 11 categories were utilized in the study.

The textbooks were analyzed to determine both the quantity and quality of the specific content regarding controversial issues and bio-social problems classified in the 11 categories. Quantitative ratings were based on the total pages in the text to the nearest tenth of a page which presented content including pertinent pictures, charts, or tables. For each category, the percentage of page space available in the text was also determined. The indexes were examined for the inclusion of the 190 key words. The table of contents was inspected for the inclusion of the categories. The qualitative ratings were based on a Likert-type scale. A median rating was calculated for each category from the subtopic ratings.

The results of the research indicated that the BSCS texts ranked highest in the quantitative and qualitative analyses for content inclusion of controversial issues and biosocial problems. In four categories the median ratings of all three BSCS Versions were higher than the ratings of Modern Biology and Biology, A Search for Order in Complexity. In ten categories, the highest median ratings which ranged from a high of 3 (adequate, lacking in depth, emphasis, or clarity) to a high of 5 (outstanding, comprehensive) were found in one of the BSCS Versions.

In four categories the total number of pages allocated by each of the three BSCS Versions was higher than the number of pages allocated by Modern Biology and Biology, A Search for Order in Complexity. In all 11 categories the highest number of pages allocated was found in one of the BSCS Versions. In ten categories the highest number of pages and the highest percentage of text space allocated was found in one or another of the BSCS Versions.

In the analyses of key words in the indexes, the highest percentages for all 11 categories were found in one of the BSCS Versions. Each BSCS Version had over 60 percent of the key words in the index. For the six categories used in the analysis of the table of contents, both the BSCS Blue Version and the BSCS Yellow Version had at least one chapter devoted to each category.

With a range in content presentation of biosocial issues both in quantity and quality in biology textbooks, the implications are quite clear. To attain scientific literacy, the use of well-prepared supplementary material is necessary for adequate coverage of controversial issues and biosocial problems.

SHOULD HIGH SCHOOL BIOLOGY BE TAUGHT BEFORE OR AFTER CHEMISTRY AND PHYSICS?

Donato Leopardi
Syracuse City School District
Syracuse, New York 13202

The purpose of this study was to analyze the educational outcomes of two different high school science sequences; the traditional sequence consisting of biology in grade 10, chemistry in grade 11, and physics in grade 12, and the new or experimental sequence consisting of physics in grade 10, chemistry in grade 11, and biology in grade 12. The two sequences were being taught simultaneously at Rome Free Academy, Rome, New York.

The primary design of this study was "The Non-Equivalent Control Group Design" (Campbell and Stanley, 1963). The subjects who participated in the experiment were high school science students enrolled in the two different sequences for New York State Regents credit.

The independent or predictor variables selected for use in the study include: treatment, sex, pre-tests in science, attitude toward science, perserverance, and self-concept of academic ability. The dependent or criterion variables were: achievement in the respective subjects (physics, biology, and chemistry), and attitude toward science.

Instruments used to measure the independent variables were administered at the beginning of the 1973-74 school year, while the tests used to measure the criterion variables were administered seven and a half months later. Multiple regression analysis was used to analyze the research data.

Among the results were the following:

1. No statistically significant differences in student achievement were observed. Sophomore physics students did as well in physics as seniors.
2. The seniors who followed the experimental sequence demonstrated significantly more positive attitudes toward science than did seniors who followed the traditional sequence.
3. Significant statistical correlations were found to exist among several independent variables and the criterion variables. Most interesting, perhaps, was the positive correlation which resulted between attitude toward science and perseverance.
4. A greater percentage of students completed the three year experimental sequence than the traditional sequence.

On the basis of results obtained in this study, it appears that:

1. The three basic high school science courses (biology, physics, and chemistry) are non-sequential.
2. Students following the experimental science sequence emerge with significantly more positive attitudes toward science than do students following the traditional sequence.
3. The sequencing of the high school science courses definitely affects student enrollments in the various science disciplines.
4. It is educationally advantageous for a student to take biology after he has had physics and chemistry.

Campbell, D. T. and J. C. Stanley. "Experimental and Quasi-Experimental Designs for Research." Chapter in Handbook of Research in Teaching, N. L. Gage (ed.). New York: Rand McNally and Company, 1963.

A TAXONOMY OF SCIENCE CONCEPTS

Alan M. Voelker
Northern Illinois University
DeKalb, Illinois 60115

A rationale for developing a taxonomy of science concepts will be presented. The rationale will be accompanied by an initial approximation of the taxonomy. Illustrations will be given as to how the absence of a taxonomy impedes the progress and quality of research on science concept learning. Recommendations will be made as to how the taxonomy should be used in designing studies on science concept learning.

This paper is the next step in a series of activities designed to improve the research on science concept learning. The initial step was an analysis of the existing research on science concept learning; followed by preparation of a paper on needed lines of research that was delivered at the 1975 NARST meeting.

Using the aforementioned base, current thought and research on development, learning, and the origins and structures of science concepts will be further examined. A network of variables to consider will be identified and used to develop the taxonomy. The nature of the taxonomy will be analyzed and discussed in light of directions for research on science concept learning.

The basis for this paper will consist of research and other scholarly literature in science, science education, and education which deals with the nature of concepts and concept learning. Special attention will be given to those pieces of research which acknowledge the role of theoretical structures and models in advancing knowledge.

The result(s) will be further refinement of a conceptual framework for conducting research on science concept learning. In particular, there will be made available to the science education research and evaluation communities a model for characterizing the concepts students are to learn or have learned.

To date, most studies on science concept learning have proceeded as if all concepts had the same characteristics. Even task analysis, concept hierarchies, subsuming concepts, etc., have not been cast in terms of the nature of the science concept(s) under investigation. Therefore, there is limited evidence accumulating which can be used in theory development or model formation. The proposed taxonomy would be a direct attack on this deficiency. It would be a productive way to re-examine the work of the past and give direction to future efforts.

The taxonomy will provide a means of studying representatives from categories of science concepts so that research on learning specific concepts will be accountable to a specific framework and can be used to generate a body of knowledge about learning classes of science concepts. Ultimately, this will lead to a generalizable model(s) for conducting research on science concept learning and development of instructional means to assist students in learning science concepts.

A CHRONOLOGICAL HISTORY OF SELECTED OBJECTIVES FOR THE TEACHING OF SECONDARY SCHOOL BIOLOGY IN THE UNITED STATES DURING THE 1918-1972 PERIOD, AS REFLECTED IN PERIODICAL LITERATURE

William R. Ogden
East Texas State University
Commerce, Texas 75428

and

Janis L. Jackson
McLennan Community College
Waco, Texas 76701

The purpose of the study was to prepare a chronological history of selected objectives for teaching biology in the high schools of the United States during the period 1918-1972, as reflected in selected professional periodicals.

The period 1918-1972 was divided into six subperiods. Selected professional periodicals were searched for statements of objectives of secondary school biology teaching. The statements obtained were categorized as knowledge, process, attitude and interest, or cultural awareness. The resulting categories were further subdivided, on the basis of similarities and differences among the statements included, into 18 distinct objectives types (five knowledge, three process, five attitude and interest, and five cultural awareness). Statements of the 18 objective types were classified as to frequency of occurrence, category, authorship, and year of publication within each subperiod and across all subperiods to serve as indicators of preference. The 1918-1972 period was divided into subperiods on the basis of selected events that were judged to have had an impact on the course of American educational history. In all cases some overlapping of subperiods was planned to allow for the gradual transformations characteristic of historical change. The subperiods were as follows:

Subperiod 1:	1918 - 1933
Subperiod 2:	1932 - 1941
Subperiod 3:	1939 - 1946
Subperiod 4:	1945 - 1957
Subperiod 5:	1954 - 1964
Subperiod 6:	1963 - 1972

The following periodicals were read in an attempt to sample the literature available during the time period in question.

School Science and Mathematics (1918-1972)
Science Education and The General Science Quarterly (1918-1972)
The Science Teacher and The Illinois Chemistry Teacher (1934-1972)
The American Biology Teacher (1939-1972)
The Bulletin of the Atomic Scientists (1945-1972)
The Journal of Research in Science Teaching (1963-1972)

Although yearly fluctuations existed with respect to both numbers or articles and statements concerned with the objectives for teaching secondary school biology that appeared in the selected periodicals of the 1918-1972 period, the number of distinct objective types remained constant. All 18 of the objectives identified were found in the literature of all 6 subperiods. Most of the changes with respect to the frequency with which objectives appeared in the periodicals selected occurred during subperiods 4, 5, and 6. The following summaries refer to variations in the frequencies of the seven most prevalent objective types.

1. Although decreasing in frequency throughout all subperiods, statements relating to the study of "specific topics in biology" were most frequent throughout the entire 1918-1972 period.

2. Also decreasing in number following subperiod 2, statements stressing "interest and hobby development" were second in frequency throughout the fifty-five years studied.

3. Third in total frequency, statements calling for the development of "scientific methods of thinking" were most prevalent following the World War II years.

4. Statements relating to "the application of biology to daily life," fourth over-all, were most prevalent during the first four subperiods.

5. Concern for the "major facts, principles, concepts or fundamentals" of biology, as reflected by appropriate statements although never really pronounced during any one subperiod, were fifth in frequency over the entire study.

6. References to "processes, skills, and techniques of inquiry," sixth over-all, were most pronounced during subperiods 5 and 6.

7. Objective statements stressing the "career development" aspects of biology teaching were most prevalent during subperiods 4 and 5.

This paper represents another phase in a large project dealing with a history of science teaching in the United States. The first phase dealt with secondary school chemistry while the present deals with biology. It is hoped that these studies, and others like them, will, in time, lead to the development of a competent history of science education.

A SURVEY OF THE PROCEDURES UTILIZED BY SECONDARY SCHOOLS IN THE SELECTION OF SCIENCE TEXTS AND PROGRAMS FOR MAJOR CLASSROOM USE*

William H. Ward, Jr.
University of Minnesota
Minneapolis, Minnesota 55455

Questions have arisen as to actual current practice among schools in the task of selecting a science text or program for use. The literature provides several suggested procedures, models, and single case studies, but little in the way of comprehensive hard data. The Selection Procedure Survey was undertaken, in part, to help fill this void.

Basic questions the study was to address were:

1. Who within a school setting is active in selection of text and program materials?
2. Do any of three proposed models adequately reflect the process as it happens in a significant proportion of school settings?
3. Is the selection procedure used identifiably dependent on national region, level of school, size of school, or type of district served?

Decision elements, individuals and groups thought potentially active in program selection processes, were identified. For each school sampled, each element was classified as active in an initial selection procedure, active in approving a selection previously made by another party, or generally inactive in the entire process.

Fits of the data to three proposed models of the selection process were attempted. Cases were sorted on the dimensions stated in objective (3) above and the patterns of elements classified as active in initial selection and in approval were compared.

Data were solicited by mail questionnaire from principals of 200 secondary schools. Schools were randomly selected from five regions of the United States previously identified by the National Science Foundation as of interest relative to its former comprehensive programs in teacher education. Final response rate was 81 percent.

The following findings resulted:

1. In secondary schools, classroom teachers either functioning independently or as committee members are involved in 97 percent of decisions in which a text or program is selected from a set of alternatives; the initial selection decision. Administrators, by comparison, are involved in 37 percent

---

*This study was supported by Grant GW-6800 from the National Science Foundation.

of such decisions. In almost all cases, however, the specific text or program selected must subsequently be approved by at least one administrator.

2. Each of the three proposed models of the selection process reflects the procedure of at least 15 percent of the cases sampled.

3. No identifiable differences were noted in the selection procedure across national region, school level, or type of district served. A slight indication of greater individual autonomy in both large and small schools, as compared to greater reliance on committee work in middle sized schools, was observed.

The study suggests that no one model of the text selection process is likely to be adequate for all cases. It also indicates that a large proportion of selection decisions are made by formal groups of individuals rather than by the individual independently. This fact has implications for those desiring to effect change in a school.

GENERAL SESSION II

Presiding: O. Roger Anderson, Teachers College, Columbia University, New York, New York 10027

Speaker: Nathan S. Washton, City University of New York, Flushing, New York 11367

Vaden Miles Memorial Lecture

"Teaching the Impact of Science on World Technology"

CONCURRENT SESSIONS VII

Session VIIA - Symposium

Presiding: Ertle Thompson, University of Virginia, Charlottesville, Virginia 22903.

"Science Education at a Funding Crossroad--

Assessment for Future Direction"

Ertle Thompson
University of Virginia
Charlottesville, Virginia 22903

Mary Budd Rowe
University of Florida
Gainesville, Florida 32601

Ernest Burkman
Florida State University
Tallahassee, Florida 32304

Robert E. Yager
University of Iowa
Iowa City, Iowa 52242

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota 55455

SCIENCE EDUCATION AT A FUNDING CROSSROAD--

ASSESSMENT FOR FUTURE DIRECTION

Ertle Thompson
University of Virginia
Charlottesville, Virginia 22903

Mary Budd Rowe
University of Florida
Gainesville, Florida 32601

Robert E. Yager
University of Iowa
Iowa City, Iowa 52242

Ernest Burkman
Florida State University
Tallahassee, Florida 32304

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota 55455

Members of the symposium will address themselves to the analysis of current assessment, and needed research and evaluation for decision-making relative to the future funding of pre-college science education activities. Current and future research needs will be presented from the perspectives of four different, but mutually supportive points of view:

Participant I: "Psychological Basis of Learning in Science-Unanswered Questions"

Participant II: "Continuing Needs for Curriculum Development in Science"

Participant III: "Implementation Modes for Improving Pre-College Science Education"

Participant IV: "Assessment of Comprehensive Implementation Activities"

The major objective of the symposium, as proposed, is to provide a forum for N.A.R.S.T. members to contribute to an exchange of research based ideas culminating in a compendium to be used individually, as desired, for advising or responding to appropriate committees and agencies, e.g., N.S.F., N.I.E., and the U. S. Congress.

CONCURRENT SESSIONS VII

Session VIIB - Contributed Papers: "Conceptual Models"

Presiding: Anton Lawson, University of California, Berkeley, California 94720.

1. "The Effects of Behavioral Objectives on Student Achievement in a College Level Sex Education Instructional System." Dennis S. Baker and John J. Koran, University of Florida, Gainesville, Florida 32611.

2. "The Potential for Improving Science Education Through Transdisciplinary Integration with Art Education." John E. Lutz, Central Susquehanna Intermediate Unit, Lewisburg, Pennsylvania 17837.

3. "The Effects of Written Cues on the Learning of Graphical Material." Paul Eggen, Don Kauchak and Sandra Kirk, University of North Florida, Jacksonville, Floria 32216.

4. "Examining a Model for Teaching Scientific Literacy Through Interdisciplinary Courses Focused on Science-Related Social Issues." Christopher J. Dede, University of Houston at Clear Lake, Houston, Texas 77058.

5. "Views on the Nature of Science Among College Science Faculty." George P. Durkee, College of St. Benedict, St. Joseph, Minnesota 56374 and George Cossman, University of Iowa, Iowa City, Iowa 52242.

THE EFFECTS OF BEHAVIORAL OBJECTIVES ON STUDENT ACHIEVEMENT IN A COLLEGE LEVEL SEX EDUCATION INSTRUCTIONAL SYSTEM

Dennis S. Baker

and

John J. Koran
University of Florida
Gainesville, Florida 32611

A majority of studies which explore the achievement of students receiving behavioral objectives report no significant differences between treatment groups. However, when significance was found, it was usually in favor of the groups which received specifically written objectives. The major problems with many of these studies were improper experimental design and insufficient thought regarding the role of behavioral objectives as aids to learning in a variety of instructional contexts.

Consequently, it was the purpose of this study to empirically explore the facilitative effects of behavioral objectives presented to students prior to their reading a unit of material on sexual anatomy and birth control. A secondary purpose was to conduct the investigation in a framework free of the methodological problems which have plagued similar studies.

The research hypothesis was:

Hr_1 - Subjects (Group I) receiving behavioral objectives prior to reading textual material on birth control will achieve a significantly higher criterion test score than will subjects (Group II) receiving the same text materials without objectives or a placebo group.

For the purposes of this study the following experimental design was used:

Group 1	R	X_1 (Objectives & Textual Material)	O_1
Group 2	R	X_2 (Textual Material)	O_2
Group 3	R	Placebo (Unit on Margaret Sanger)	O_3

Sixty-one students, from a community college in north central Florida, enrolled in a freshman interdisciplinary science class participated in this study. The number of males and females was approximately equal. The study was conducted in three separate one-hour sessions. Students were given one of three treatments which had previously been arranged in random order. Treatments included behavioral objectives and text, no-behavioral objectives and text, and a placebo. Students assigned to Treatment I received 14 specifically written behavioral objectives in addition to written and verbal instructions concerning their use. Treatment I students then read a unit on birth control and completed a 21-item multiple choice test based on the behavioral objectives. All groups took the same test. Treatment II students read the unit on birth control and completed the test but did not receive behavioral objectives. However, they did hear how objectives could be used during learning. Students assigned to Treatment III read a unit about Margaret Sanger, the birth control pioneer; heard how objectives could be used during learning; and then took the criterion test. The Sanger unit did not contain information which overlapped with the birth control and sexual anatomy text.

The criterion measure had twenty-one items and a Cronbach Alpha indicated a reliability coefficient of .77. The group means and standard deviations for posttest scores are reported in Table 1.

TABLE 1

Means and Standard Deviations for Treatments

	M	SD
	Posttest	
Behavioral Objectives Group	16.20000	3.833
No-Behavioral Objectives Group	12.52381	3.086
Placebo	12.36842	3.745

A one-way analysis of variance revealed significant main effects when all groups were compared. A Scheffé test comparing pairs of mean scores showed that the behavioral objectives group (Treatment I) scored significantly higher on the criterion test than did the no-behavioral objectives group and the placebo group ($p < .01$) thus supporting the research hypothesis.

The Scheffé test did not show any significant differences between the no-behavioral objectives group (II) and the placebo group (III).

The present investigation was designed to assess the effects of behavioral objectives on student achievement while trying to control major contaminating factors in earlier studies. Students who received behavioral objectives in this study performed significantly better on a criterion test than did students who did not receive objectives. It is assumed that students who received objectives were able to match information in the textual material with the objectives and therefore performed well on the behavioral objectives based on criterion measure. While all groups received information on how to use the objectives, the treatment group combining this information with specific objectives was superior. One important implication of this study is that behavioral objectives can facilitate the learning of textual material when students are told what their function is and how to use them. These findings appear consistent with a large body of research called Mathemagenic research pioneered by Rothkopf, Frase and Bell Laboratories on learning from text materials with written or pictorial adjuncts.

The structure and form of the textual material in the study was designed to be representative of text book material used in the average college classroom. Therefore, the effectiveness of existing texts in science may be increased by the addition of behavioral objectives.

THE POTENTIAL FOR IMPROVING SCIENCE EDUCATION THROUGH TRANSDISCIPLINARY INTEGRATION WITH ART EDUCATION

John E. Lutz
Central Susquehanna Intermediate Unit
Lewisburg, Pennsylvania 17837

An interdisciplinary approach to environmental education was demanded by the editors of seven journals in a declaration published in the February, 1975, issue of The Science Teacher. Not only environmental education, but other science instructional areas, too, could benefit from an integrated, interrelated, interdisciplinary, and interfluent learning approach. The purpose of this study was to analyze data collected from participants in the Pennsylvania Governor's School for the Arts (PGSA) in terms of their relevance to science education. (The PGSA is a five-week summer program for Pennsylvania's most artistically talented and gifted high school students.) Its objective was to investigate relationships between variables common to the arts and sciences as a means for hypothesizing alternative approaches for growth in scientific attitudes and skills (Can instructional activities in art areas help develop necessary science skills and attitudes?).

A regression-discontinuity design was selected to compare participant change during the PGSA program to baseline data collected before program involvement. Statistical procedures include analyses of variance, determination of intercorrelations between the 29 variables, and regression analyses.

From an initial applicant pool of nearly 2,000 tenth and eleventh grade artistically talented students from across the Commonwealth of Pennsylvania, 255 were selected for participation in the PGSA and, thus, this study. Four test instruments were administered to all participants: the Biographical Inventory (BI), Form R; the Sixteen Personality Factor Questionnaire (16PF); the Torrance Tests of Creative Thinking (TTCT), Figural Test; and the Pennsylvania Department of Education's Education Quality Assessment (EQA) Goal VII Test of Creative Performance. In addition, pre and post assessments included individual instructor ratings of student performance in skill areas appropriate to the PGSA.

At the time this summary was prepared (October), analyses of the data collected from April to September were still being conducted and results were incomplete. Final results were available in November, 1975. Available preliminary information, however, has identified several significant correlations ($p < .001$). These are summarized below.

(a) Scientific Creativity was positively correlated with BI Artistic Talent ($r = .58$, $n = 242$), 16PF factors Assertiveness and Independence ($r = .42$, $n = 231$) and Imagination and Interest in Art ($r = .40$, $n = 231$), and EQA Science Activities ($r = .46$, $n = 234$).

(b) Participation and Recognition in Science Activities is also positively correlated with BI Leadership ($r = .57$, $n = 234$) and Artistic Talent ($r = .42$, $n = 234$), and EQA Performance Arts ($r = .58$, $n = 238$).

(c) Occupational profiles for research scientists identify 16PF factors with high values which show significant correlations with BI and EQA data, which, in addition to some of the above results, included the Experimenting and Liberal factor with BI Scientific Creativity ($r = .30$, $n = 231$).

Although TTCT analyses were incomplete when this summary was prepared, and certain limitations of the study were recognized, some tentative conclusions can be made:

(a) Positive relationships exist between certain art and science education constructs.

(b) Some affective skills appropriate to the development of artistic talent are related to some personality profile factors of research scientists.

If artistic activities influence the development of certain affective and psychomotor skills required in science activities, then science instructional processes could become more efficient with transdisciplinary integration of science and art.

THE EFFECTS OF WRITTEN CUES ON THE LEARNING OF GRAPHICAL MATERIAL

Paul Eggen
Don Kauchak
Sandra Kirk
University of North Florida
Jacksonville, Florida 32216

The transmission of information in science texts is often accomplished through the use of graphs. Graphs are typically viewed as helpful adjuncts to information transmitted in prose form. However, research on the effectiveness of graphs (Vernon, 1946, Vernon, 1950) in printed material has shown that graphs often add little to the understanding of textual material and may, under certain conditions (Vernon, 1951) have a deleterious effect on learning from textual material.

Research in the area of mathemagenic behaviors had demonstrated the effectiveness of certain types of questions and cues in learning from prose materials. The function of questions or cues interspersed in textual material has been hypothesized to be one of inducing searching or attending behaviors in the reader. Such cues help to focus the learner's attention on important aspects of the text.

The present study investigates the effectiveness of different types of cues on learning information presented in graph form.

The population used in the study consisted of 143 fourth, fifth, and sixth grade students. The students were randomly assigned to one of three experimental groups. All groups read written materials describing four experiments with plant growth. The results of the experiments were presented in bar graphs but not in the written text. One of the experimental groups (General Cues) was asked to respond in writing to a general question about the results of the experiments (e.g. What are the results of the experiment?). A second experimental group (Specific Cues) responded to specific questions (e.g. In which temperature did the bean plants grow the most by the end of the experiment?). A control group was asked to notice the results of the experiments. The information reported in the graphs was designed to be counterintuitive to prevent students from correctly responding to the post test from memory or experience.

The hypothesis tested was: There is no significant difference between groups given different types of cues in the amount of information obtained from graphical material.

Subjects were post-tested on their ability to recall specific information about the experimental results as well as identify generalizations which were supported by experimental evidence. The Kuder-Richardson reliability for the post test was found to be .84.

The results of the analysis of variance showed significant difference ($P < .01$) among the group means which led to a rejection of the null hypothesis. Further analysis of the total test scores showed the test scores for the Specific Cues group to be significantly higher than Control ($P < .01$) and the General Cues ($P < .01$).

The results showed that for the population studied, specific cues resulted in significantly greater recall of graphical information than either general cues or a control group.

Additional studies are now under way which are designed to measure the effects of different types of graphs as well as the effects of different types of cues on learning from graphs.

As noted in the introduction, Vernon has shown that graphical material can actually confuse rather than clarify text material for students. This is particularly disconcerting in science where much information is presented to students in graphs.

However, the present study suggests that much of the difficulty arises from either a lack of attention on the part of the student or his inability to focus upon the salient aspects of graphs. The results of the study also suggest that these learning difficulties can be partially remediated by the use of cues that focus the students' attention on particular aspects of graphical material. If future studies corroborate the positive effect of cues, these results will have important ramifications for the writers as well as the users of science text materials.

Vernon, M. D. "Learning From Graphical Material." British Journal of Psychology, 1946, 36, 145-157.

Vernon, M. D. "The Visual Presentation of Factual Data." British Journal of Psychology, 1950, 40, 174-185.

Vernon, M. D. "Learning and Understanding." Quarterly Journal of Experimental Psychology, 1951, 3, 19-23.

EXAMINING A MODEL FOR TEACHING SCIENTIFIC LITERACY THROUGH INTERDISCIPLINARY COURSES FOCUSED ON SCIENCE-RELATED SOCIAL ISSUES

Christopher J. Dede
University of Houston at Clear Lake
Houston, Texas 77058

At the 1975 NARST Annual Meeting, a panel on "Do Science-Related Social Issues Belong in Science Courses?" and a symposium on "Scientific Literacy: The Concept ond the Future" were presented. This paper will apply the theoretical and conceptual perspectives developed in those presentations to emerging science/society programs at a new upper-level campus in the University of Houston system.

The model upon which these emerging programs are based is designed for flexibility, so that the different types of scientific literacy appropriate to scientists, science teachers, or citizens can be developed within a single overall framework. The concepts and processes appropriate to each type of scientific literacy over the next thirty years are continuously defined and examined by working groups of scientists, educators, social scientists, and figures researchers. These concepts and processes are conveyed through utilizing likely future science-related social issues as the basis for course goals and experiences. The concept of guided self-selection within a range of integrated, university-wide, interdisciplinary courses is central to the model, as it allows upper-level students with significant work-related experience to choose learning experiences most suited to their abilities and interests.

The paper will include:

a) a summary of the overall model for these interrelated, multidisciplinary science/society programs.

b) the results emerging in this model appropriate to the theoretical perspectives delineated in the NARST "science-related social issues" panel (on questions of the best disciplinary locus for science-related social issues; optimum teaching style, instructional background, and grade level; appropriate instructional objectives (cognitive and affective); and ethical problems.

c) the results emerging from the model appropriate to the theoretical perspectives delineated in the NARST "scientific literacy" symposium (on questions of the conceptualization and definition of scientific literacy, needed directions and research investigations for science education to realize this concept, and the relationship of scientific literacy to planning for alternative futures).

d) a discussion of the generalizability of exploratory research on this model to other settings.

The application of these conceptual constructs to a concrete, on-going set of programs facilitates identifying areas in which these constructs are most useful and possible gaps in the theoretical perspective.

VIEWS ON THE NATURE OF SCIENCE AMONG COLLEGE SCIENCE FACULTY

George P. Durkee
College of St. Benedict
St. Joseph, Minnesota 56374

and

George Cossman
University of Iowa
Iowa City, Iowa 52242

The purpose of the study was (1) to identify and assess the views, beliefs and opinions of university/college natural science faculty in the United States on the nature of science, (2) to indicate on what issues there is consensus, (3) to specify differences in viewpoint or perspective between academic scientists and a group of philosophers of science, and (4) to investigate the relationships between scientists' views on the nature of science and various demographic variables.

The variables used in the study were: (1) demographic variables--vocation, area of science, type of educational institution, highest academic degree held, exposure to literature on the nature of science, extent of previous thought about issues in the criterion instrument, age and geographical region; (2) dependent variables--views or perspectives concerning numerous aspects and dimensions of the nature of science. To measure the dependent variables an instrument was constructed, called an Inventory of Views on the Nature of Science (IVNS). IVNS contained 44 items in a multiple choice format. The respondents could mark more than one response on a given item and they could add free responses. Fifteen scales were formulated from item-response statements.

The sample consisted of 318 randomly selected science faculty in the biological, physical and earth sciences. In addition, 23 prominent philosophers of science were surveyed. The criterion instruments were administered by mail.

The results indicated that both groups maintain the perspective that science is the process and product of a dynamic man-world interaction rather than the literalistic description of nature. Both groups hold the perspective that science is characterized by the interaction of its cognitive structure with the community self-consciousness and social dynamic, resulting in the establishment of 'confident' theories, rather than the perspective that science is characterized by the externality and independence of its cognitive structure from the community self-consciousness and social dynamic.

Both groups affirm that the chief aim of science is to search for pattern and coherence in nature via theoretical structures, in preference to collecting and categorizing all facts and laws of nature or to furthering the well-being of humanity. Among the scientists some differences were observed between areas of science, type of educational institution and highest academic degree held. Scientists clearly favor the view that scientific laws are empirical generalizations over the view that they are confirmed theories or certain reports of inviolable relations. In contrast, the philosophers exhibit no significant preference between the first two views.

Other results showed that while the philosophers generally reject the "instrumentalist" position with regard to scientific theories, a majority of the scientists accept it. Numerous issues dealing with theoretical terms, objectivity, verification and falsification, science and society, presuppositions of scientists, processes of "sciencing," science vs. other disciplines, and other topics were investigated.

The significance of the study is that for the first time science educators have extensive empirical information on the philosophical views of the academic scientific community. This information may provide a basis for what is taught about the structure, assumptions, aims, and processes of science. It may also be used as an empirical base for evaluation instruments used to assess students' understanding of the nature of science.

CONCURRENT SESSIONS VII

Session VIIC - Contributed Papers: "Learning"

Presiding: Richard L. Campbell, Florida International University, Miami, Florida 33144.

1. "A Logical Operations Model of Science Content Comprehension." Ronald J. Raven, State University of New York at Buffalo, Buffalo, New York 14214.
2. "An Experimental Study of the Placement of Classification Skills in the Science - A Process Approach Curriculum Employing Piaget's Theory of Cognitive Development." Theodore M. Johnson, The Pennsylvania State University, University Park, Pennsylvania 16802.
3. "A Piagetian Task Considering the Double Variable of Mass and Volume by Preservice and Inservice Elementary School Science Teachers." Carl F. Berger, University of Michigan, Ann Arbor, Michigan 48104.
4. "A Study of the Performances of Elementary School Children in Western State of Nigeria on Science-Related Piaget-Like Tasks." Diran A. Taiwo, University of Ife, Ile - Ife, Nigeria.
5. "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects." Walter E. Lowell, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

A LOGICAL OPERATIONS MODEL OF SCIENCE CONTENT COMPREHENSION

Ronald J. Raven
State University of New York at Buffalo
Buffalo, New York 14214

Science content comprehension has eluded investigation because of the absence of an operationally defined model. A content comprehension model must include the logical structures used to organize the science concepts. Concepts that are classificatory in nature may be easier to comprehend than concepts that use compensation or proportion to organize the information. Reading comprehension tests do not assess the major logical operations that are used in science comprehension. The reading comprehension tests use a considerable amount of critical thinking which involves analysis and evaluation processes rather than synthesis or construction processes.

The work of Jean Piaget and others indicates that science concept formation and comprehension depends upon the presence of specific operative structures or logical operations. Piaget's work also shows that the comprehension of a concept occurs when the individual actually engages in the construction of a concept. A model of science content comprehension was constructed using the following logical operations: classification, seriation; logical multiplication; compensation; ratio; probability; and correlation. The model required the individual to use these logical operations.

A 42-item instrument was constructed using the comprehension model. There were six items that used each logical operation and each item required the individual to construct a concept from information given in a paragraph. The test was administered individually to 40 sixth graders, 40 eighth graders and 40 elementary school teachers. Each of the subjects was asked to draw how he or she answered the question and then asked for a reason why they answered the question the way they did. The test was administered to each individual in three one hour settings.

The results of a Friedman two-way analysis of variance show that there are significant achievement differences among the items that use different logical operations. The compensatory operations items are the most difficult types of items. This is interesting because ratio thinking is often considered to be more difficult than compensatory thinking. According to Piaget, ratio thinking occurs after compensatory thinking.

The results of a Kruskal-Wallis one-way analysis of variance test show that there were significant differences among the three groups. The teachers made the highest scores and the sixth grade students made the lowest scores.

An analysis of the drawings of the subjects was made by five judges. The analysis showed that the adult subjects who correctly answered the questions were able to construct drawings that showed the logical operations relationships. Significantly less of the sixth and eighth grade students were able to draw the logical operations relationships required to answer the questions.

There appears to be a relationship between achievement on science content comprehension and the ability to draw the logical relationships.

The results of this study show that the achievement on science content comprehension items using logical operations does not follow Piaget's description of the development of these logical operations. Content comprehension must be assessed within the reading context since the majority of the science concepts are obtained in this fashion. The logical operations model of science content comprehension is one approach to assessing the individual's capability of comprehending content at different levels of complexity.

AN EXPERIMENTAL STUDY OF THE PLACEMENT OF CLASSIFICATION SKILLS IN THE SCIENCE - A PROCESS APPROACH CURRICULUM EMPLOYING PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

Theodore M. Johnson
The Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of this study was to investigate whether success in Science - A Process Approach's (S-APA) process of classification designed for primary grade children is contingent upon the children's developmental level as defined by Piaget's theory.

The investigator sought to determine whether children who had reached the concrete operational stage of intellectual development are more likely to succeed on S-APA exercises requiring multi-classification ability than their primary classmates who are at the defined pre-operational level.

The study was developed in four phases. During phase 1, the investigator and an independent judge made a task analysis of nine of eleven classification exercises in S-APA's primary grade contingent that were designed for grades K-2. This analysis employed the research findings of Piaget and Inhelder (1964), Kofsky (1966) and Allen (1967). This task analysis became the basis for the hypotheses in the study.

In phase 2, a selected sample of 30 children was chosen. These children were assigned to the two developmental groups in question, pre-operational and concrete operational, on the basis of their performance on two independently administered diagnostic instruments, the Concept Assessment-Kit-Conservation (CAK-C), Part A, and the Kofsky Classification Scale (KCS). The Otis-Lennon Mental Maturity (O-L MM) test was administered to obtain a mental age score for the children. Matched pairs, one from each developmental stage, were formed with each child in the pair having a mental age score within one standard error of one another as indicated by the results of the Otis-Lennon Mental Maturity Test. These matched pairs were then assigned randomly to two teacher instructional groups (TIG_1 and TIG_2).

The teaching of nine sequentially-arranged classification exercises as prescribed by S-APA were taught in phase 3.

Phase 4 consisted of administering individually the exercise compentency measures accompanying each of the nine S-APA lessons.

The data consisted of the scores from the nine individually administered competency measures accompanying the S-APA classification exercises for thirty children, fifteen pre-operational and fifteen concrete operational.

To determine whether differences existed between the scores of the two developmental groups, the experimental design employed a two-factor analysis of variance with factor A (developmental level) crossed with factor B (teacher). The investigator selected the Analysis of Variance with Repeated Measures (ANOVR).

The significant findings in this study were manifested in seven of the nine S-APA classification exercises between the developmental groups. As predicted, the concrete operational group performed significantly better, at the .05 level, than the pre-operational groups in three S-APA exercises requiring hierarchical classification. Differences of significance were also found in four S-APA exercises requiring exhaustive sorting.

No significant differences were found for any of the lessons between children in the developmental group assignments. No interactional effects between Teacher Instructional Groups and developmental groups were found in any of the exercises.

Science curricula compatible with or strictly based on Piagetian theory have appeared just within the last decade. The tentative findings in Piagetian experimentation suggest that the operational levels do influence results in achievement of specific science lessons involving distinct mental operations of these levels. Science curriculum specialists may draw two essential elements from Piagetian theory when constructing the structure of curriculum experiences. First, certain processes, such as classification skills, seem to develop in an orderly sequence of steps. Learning experiences in carefully ordered steps of prerequisites might ultimately lead to more profound higher-order process skills. Secondly, children at different developmental levels may find specific skills beyond their level of comprehension if adequate sequences of prerequisites are not provided.

Allen, Leslie R. "The Classification Ability of Children Who Have Been Exposed to One of the 'New' Elementary Science Programs." Unpublished doctoral dissertation, University of California at Berkeley, 1967.

Goldschmid, M. L. and P. M. Bentler. Concept Assessment Kit-Conservation. San Diego: Educational and Industrial Testing Service, 1968.

Inhelder, B. and J. Piaget. The Early Growth of Logic in the Child. London: Routledge and Kegan, Paul Ltd., 1964.

Kofsky, Ellen. Developmental Scalogram Analysis of Classificatory Behavior. Doctoral dissertation, University of Rochester, 1963.

A PIAGETIAN TASK CONSIDERING THE DOUBLE VARIABLE OF MASS AND VOLUME BY PRESERVICE AND INSERVICE ELEMENTARY SCHOOL SCIENCE TEACHERS

Carl F. Berger
University of Michigan
Ann Arbor, Michigan 48104

The objective of the study was to design a Piagetian-like task that could be used with college and university students who might range from preconcrete operational to formal thinking. Traditional tasks to indicate discrete developmental levels have been designed by Piaget and others to give dichotomous information of one developmental stage or another. Multiple tasks of this type must be used to determine the developmental level of adults. Furthermore, such tasks are often administered on a one-to-one basis and are inappropriate to the time and resources available at a university level where limited class sessions are the rule.

Karplus and Karplus have devised a technique that deals with data on more than two Piagetian stages and have continued to pursue discriminations of cognitive thinking levels beyond adolescence. This study was designed to expand and test such techniques of single tasks in group situations. Further, the tasks were tested with university students and elementary school science teachers.

The task was designed using basic criteria inferred from tasks described by Piaget, Inhelder, Karplus and Karplus and Raven:

1. Each task requires the subject to select or indicate an equality or inequality of property;

2. Reasons for selecting must be given to indicate thinking process to determine the equality or inequality; and

3. Each task is based on real materials, either manipulated by or in full view of the subject.

The task designed was entitled "Marbles and Water." "Marbles and Water" involved using three vials of water filled to the same volume and three marbles. The first marble was a large glass sphere; the second marble was a large steel sphere of the same volume as the glass sphere, but greater in mass; the third marble was a small steel sphere which had less volume than the first sphere but had the same mass. The first sphere was gently lowered into the liquid and the level was noted. The second sphere was shown to or handled by the subjects, and without lowering the sphere into the liquid, the subjects were asked to predict the level of the liquid and the reasoning used to support their predictions. The same was done with the small steel sphere.

Over 300 university students, including undergraduates and graduates in preservice elementary school science, were tested with "Marbles and Water." Further testing was done with teachers not involved in university course work; 158 inservice teachers participated in this phase of the testing. Results gathered were collated and placed on a matrix utilizing the reasoning given for each question.

The matrix used to evaluate the subjects indicated whether the subjects had consistent responses in predictions about marble two and marble three or whether they were inconsistent in chosing mass or volume as a reason for prediction of liquid level.

Results indicated a significant difference between preservice students and teachers not involved in education programs. Also in each subject group, formal concrete and preconcrete stages were noted in significant proportions.

Given the results of this project, consideration should be given to the design of activities for university students preparing to teach in elementary schools. Such activities should consist of concrete as well as formal thinking activities. Further education for inservice teachers with emphasis on concrete activities also may be appropriate.

A STUDY OF THE PERFORMANCES OF ELEMENTARY SCHOOL CHILDREN IN WESTERN STATE OF NIGERIA ON SCIENCE-RELATED PIAGET-LIKE TASKS[1]

Diran A. Taiwo
University of Ife
Ile - Ife, Nigeria

The purpose of this study was to investigate the performances of elementary school children in Western State of Nigeria on science-related Piaget-like tasks[2]. Deriving from this general statement of the problem of this study are the following subproblems:

i. To determine whether elementary school children in the fourth, fifth, and sixth grades in Western State of Nigeria differ in their performances on Piaget-like tasks, and

ii. To determine whether elementary school children in urban areas of Western State of Nigeria differ from their non-urban counterparts in their performance on Piaget-like tasks.

In a nutshell, the theoretical framework of this study centers around educational theories dealing with "spontaneous" and "non-spontaneous" learnings, the principle of readiness, and the relationship between culture and cognition.

After giving due consideration to the cultural background of the population of this study and the nature of the subject matter concerned, the investigator constructed a 20 activity interview guide for the study. Copies of the guide were then given to three psychologists for validation purposes. This was followed by a reliability exercise which involved the exposure of 120 subjects to a modified version of the guide. The responses of the 120 subjects were then analyzed statistically using the split-half method and Spearman-Brown formula. A reliability coefficient of 0.692 was obtained for the instrument.

With the aid of a trained assistant, a total of 979 school children in classes four, five and six in Western State of Nigeria were exposed to the research instrument.

---

1. This paper is derived from a doctoral dissertation submitted to the School of Education of New York University in March, 1975.

2. These are simple Piagetian experiments which can be used to study child's thought and reasoning concerning conservation of distance, length, of continuous and discontinuous quantities and of weight; and concepts of relative height, displacement, speed, time and relative weight.

Among other things, it was found that the school children whose ages ranged between 9 and 11 years could be said to have reached what Piaget termed "concrete level" of development in most of the tasks of this study. In addition, it was found that there is a difference in the performances of fourth, fifth and sixth graders on the Piaget-like tasks with progression in achievement according to grade level. It was also found that there is a significant difference between the performances of school children in the urban and non-urban areas of the state on the Piaget-like tasks. In this case, the urban children showed superiority over their non-urban counterparts in almost all the activities of this study.

This study is important for both theoretical and practical reasons, viz:

i. It opens up new vistas of knowledge concerning the performances of Nigerian children (between the age bracket of 9 and 11) on Piaget-like tasks, and

ii. It has implications for both content selections _cum_ grade placement and teaching methods in that the outcome of the study was able to identify the strengths and weakness (in terms of misconceptions) of the subjects on the science-related Piaget-like tasks.

A COMPARATIVE STUDY OF ABSTRACT LEARNING IN MENTALLY RETARDED AND NORMAL SUBJECTS

Walter E. Lowell
Memorial University of Newfoundland
St. John's, Newfoundland, Canada

The purpose of this study was to explore the role of abstract thinking in human learning. A hierarchical model of abstraction and a test based on this model were constructed. One dimension of the model, the Order of Classification, was evaluated using mentally retarded and normal ability subjects. The evaluation consisted of a hierarchical test constructed to determine whether human subjects order their world in hierarchical arrays and the relationship of mental ability to this process.

The hierarchical test was based on a model of abstraction which designated three distinct modes of representing experience. These three representational modes were called Orders and defined as follows: The Order of Classification dealt with attribute to class categorization; the Order of Relations, with logical and/or causal connections between attributes, objects, and classes; the Order of Operations, with transformations of one thing (i.e., entities in the foregoing Orders) into something else. The three Orders are hierarchically arranged and sequenced to denote concrete, sense data experience at their lowest levels (classification) to entirely symbolic representations at their highest levels (Relations and Operations). Further, each Order of representation was considered to be a hierarchy in itself; the lowest order, Classification, was considered fundamental to the higher orders and was therefore systematically explored.

The Order of Classification test was based on a six-level Natural Things hierarchy. The first two levels consisted of attribute identification (non-verbal identification of attributes) and attribute recognition (verbal naming of attributes); the subsequent levels were as follows: Level III, Object Recognition; Level IV, Class Recognition; Level V, Class of Classes Recognition subsuming one class; Level VI, Class of Classes Recognition subsuming two classes. To measure all six levels, eight subtests were used (two subtests were used for Level IV and Level V).

The subtests consisted of an example box which contained two concrete examples of the instance to be learned and the test box which contained two different concrete examples of the instance taught, plus four distractors. The Ss were taught the correct instance with the example box and then were asked to find these two instances in the text box. Since the level of abstraction in the test sequence increases from Level I to Level VI, due to an increase in generality and inclusiveness, the degree of difficulty for each test increases commensurately.

The mentally retarded subjects were compared with mental age and chronological age equivalents and, in both cases, the results indicated statistically significant differences in performance on the test. These results support previous studies which allude to the strong dependence of the mentally retarded child on concrete cues and suggest that the mentally retarded may be incapable of organizing information into conceptual hierarchical arrays. In addition, the results support the hierarchical model of abstraction and, in particular, the validity of the classification test.